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ABSTRACT

This document is a compilation of eight papers which present the advantages of, and the need for, the systems approach in all areas of education. The first paper, an explication of the SIGGS theory model, explains set theory, information theory, and graph theory, and demonstrates their integration. Project PRIME, concerned with the mainstreaming of mildly mentally handicapped students, is used as an application of SIGGS to educational research in the second paper. The third describes the use of process models in an actual field training program in health professions education. The fourth considers a test of the validity of Atkinson's achievement theory. In the fifth paper, the effective use of instructional systems technology to meet the needs of individualized education is emphasized. The sixth paper describes management models, organizational models, and instructional models and their interrelationships, and the need for optimizing educational resources in Army schools by stressing planned change is presented in the seventh. The last paper discusses the cost effectiveness of computer managed instruction in the Navy. (RAA)

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SYSTEMS RESEARCH IN EDUCATION

T. Antoinette Ryan

Editor

University of South Carolina

Columbia, South Carolina

December 1978

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FOREWORD

The need for the systems approach in the field of education is great. Educational research, as well as innovative educational programs, can benefit tremendously from the systems approach. For much too long, educational experiences, including those outside the formal educational setting, have been lacking in unity and firm purpose. Students and educators alike can benefit from the improvement in educational planning, research, and methodology which results from consistent implementation of the systems approach. This publication presents a compilation of eight papers which set forth the advantages of and the need for the systems approach in all areas of education.

The first paper, by Elizabeth Steiner and George S. Maccia, explicates the logic of the SIGGS theory model. They explain set theory, information theory, and graph theory; then demonstrate that an integration of these three theories with general systems theory produces a very efficient paradigm for describing any system. Ted Frick discusses the evolution of general systems models and stresses the superiority of the extended general systems approach (SIGGS) to other approaches. Frick presents a portion of Project PRIME, concerned with mainstreaming mildly mentally handicapped students, as an example of the application of SIGGS in educational research. Rodger Marion discusses the philosophy of using models to aid in the development of educational programs. He presents an example of using process models in an actual field training program in health professions education at the University of Kentucky. Kenneth B. Loose and Waldemar R. Unruh consider Atkinson's achievement theory, which states that anticipated success or failure will influence the impression of a task and the response produced. They present data selected from learning research conducted by Feather to test the validity of the educational model developed from achievement theory. Paul J. Dudgeon emphasizes the need for individualized education, which can effectively be met through instructional systems technology. He explains instructional systems technology and provides examples of how it has been used at Canadore College in Alberta, Canada.

The sixth paper, by Roger Kaufman, describes management models, organizational models, and instructional models, and suggests an interrelationship among these models. John P. Furman discusses the need for optimizing educational resources in Army schools. He presents a plan for implementing the needed changes at the United States Army Signal School, stressing the need for planned change rather than haphazard efforts. Duncan N. Hansen, Steven M. Ross, and Harry L. Bowman present the cost effectiveness of the computer managed instruction used in the Navy. They discuss the financial aspects as well as the attitudes of the students, instructors, and other people involved with the system.

Columbia, South Carolina
December, 1978

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CONTENTS

Foreword i

The Logic of the SIGGS Theory Model
Elizabeth Steiner and George S. Maccia 1

Application of SIGGS to Project PRIME
Ted Frick 15

An Approach to Instructional Design Using Successive Models
Rodger Marion 53

An Analysis of Interaction of Anxiety, Aspiration Level and Ability Derived from Ecological Systems Theory
Kenneth B. Loose and Waldemar R. Unruh 69

An Instructional Systems Technology Model for Institutional Change
Paul J. Dudgeon 89

Management Models, Organizational Models and Instructional Models
Rodger Kaufman 109

Implementation of Interservice Procedures for Instructional Systems Development: A Planned Process for Change
John P. Furman 115

Cost Effectiveness of Navy Computer Managed Instruction
Duncan N. Hansen, Steven M. Ross, Harry L. Bowman 123

THE LOGIC OF THE SIGGS THEORY MODEL

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This is an explication of the logic of the SIGGS Theory Model. To set forth logic is to explicate order, i.e., function with its attendant structure. The paper is constituted of two parts: one treating SIGGS' pragmatics and the other SIGGS' semantics and syntactics.

SIGGS' Pragmatics

The SIGGS Theory Model has been formulated in order to provide a conceptual paradigm for describing any system whether it be physical, biological, or hominological. Maccia (Note 1) defines hominological to characterize knowledge about human beings. Consequently, SIGGS is for describing atoms as well as educational organizations. Since SIGGS is for devising generalizations which characterize the properties of any system and the interrelations of these properties, it is a general system theory, as defined by von Bertalanffy (1968).

Given SIGGS' inherent descriptive function, instrumental functions obtain. When one can characterize systems, one can devise them. Understanding permits designing. Also when one can characterize systems, one can account for their being and can foretell what they will be. Understanding also permits explanation and prediction. When one can diagnose or prognosticate, one can direct the course of events. Understanding, therefore, through explanation and prediction, permits control.

Figure 1 summarizes the pragmatics of the SIGGS Theory Model. The

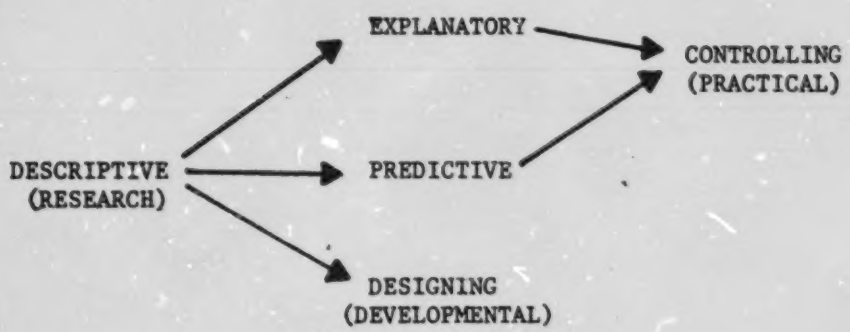


Figure 1: Pragmatics of SIGGS

model functions in research to generate knowledge about systems. From this inherent descriptive function arise three other functions:

explanatory, predictive, and designing. Two of these three instrumental functions give rise to yet another instrumental one, i.e., the explanatory and the predictive functions give rise to the controlling one. This last mentioned function is the practical one, while the earlier mentioned designing function is developmental in nature.

SIGGS' Semantics and Syntactics

The SIGGS Theory Model was formed by integrating set (S), information (I), and graph (G) theories with general systems (GS) theory. This integration is depicted in Figure 2. Because set theory is basic to both

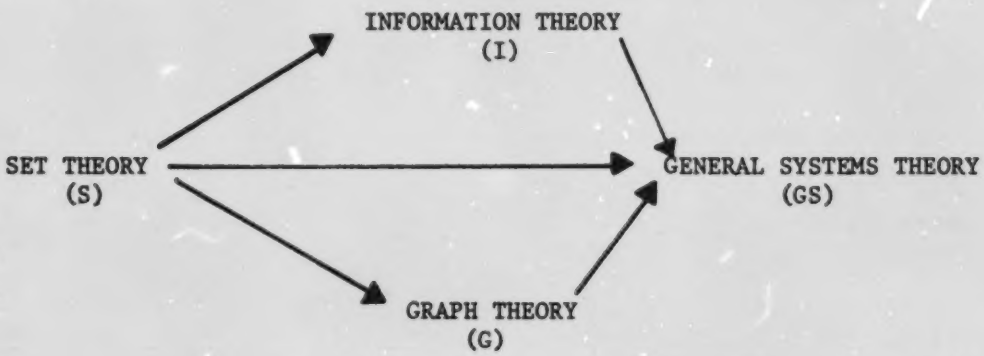


Figure 2: The SIGGS theory model

information and graph theories, in the depiction set theory is related to general systems theory not only directly but also indirectly through information and graph theories.

Set theory is a mathematical theory which characterizes sets. "Set" is a primitive term which cannot be defined. However, one can explicate it intuitively by means of alternative referents. A set can be thought of as a collection, a class, an aggregate, a group. From these alternative referents, a set usually, although not always, has something within it which could be considered as belonging to the set: the objects of the collection, the members of the class, the points of the aggregate, the components of the group, etc. That which belongs to the set is called "an element." Moreover, the objects, members, points, components can themselves be taken as sets of elements; and if they are so taken, then the collection, the class, the aggregate, the group, etc. can be thought of as families of sets.

The use of set theory can give precision to von Bertalanffy's definition of system as a complex of elements standing in interaction (von Bertalanffy, 1968). The complex of elements is interpreted as a set, and hence as elements forming a unit. To illustrate, teacher, student, curriculum, and setting form an educational system. "Educational system" is not used in its restricted sense of a complex of

interrelated schools, colleges, or universities. In this restricted sense, an educational system is a system of educational systems. In set theoretic notation:

$$E = \{t, s, c, g\}$$

where 'E' stands for educational system
't' stands for teacher
's' stands for student
'c' stands for curriculum
'g' stands for setting

In a set, the elements form a unit within a universe of discourse. To continue the illustration, an educational system can be considered in the context of the state. Also it can be considered within other universes of discourse, e.g., the home or the church. It cannot be considered within any universe of discourse. The unit must be consistent with the universe of discourse. It does not make sense to consider an educational system in the context of a molecule.

Given a set within a universe of discourse, the universe which is not the set is its complement. This set theoretic notion of complement gives precision to a system's surroundings or to what is not system. What is not system is called "negasystem." In the illustration of an educational system within the context of the state, the surroundings consist of persons, culture, and objects within the state but not within the educational system.

Figure 3 summarizes the illustration of the use of the set theoretic notions in delineating a system and its surroundings. It should be noted

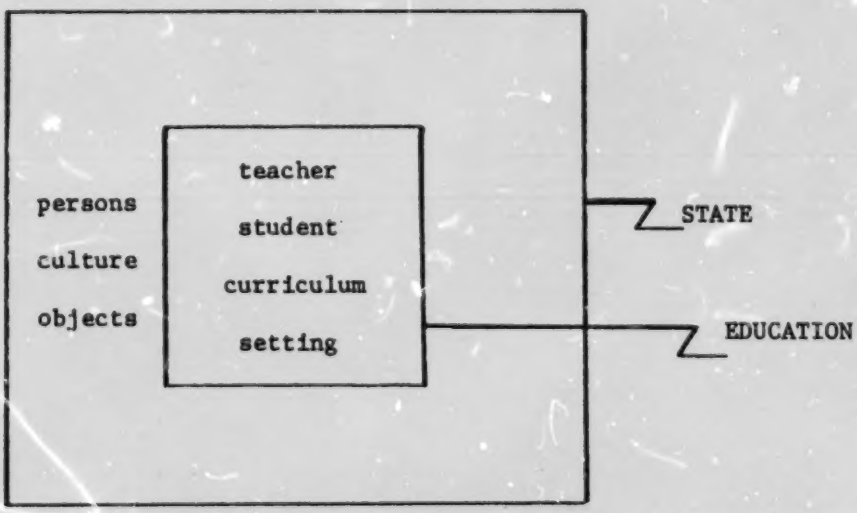
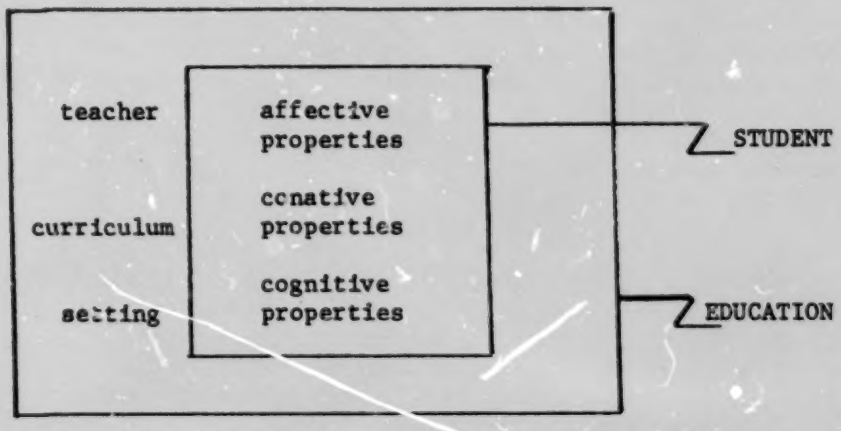


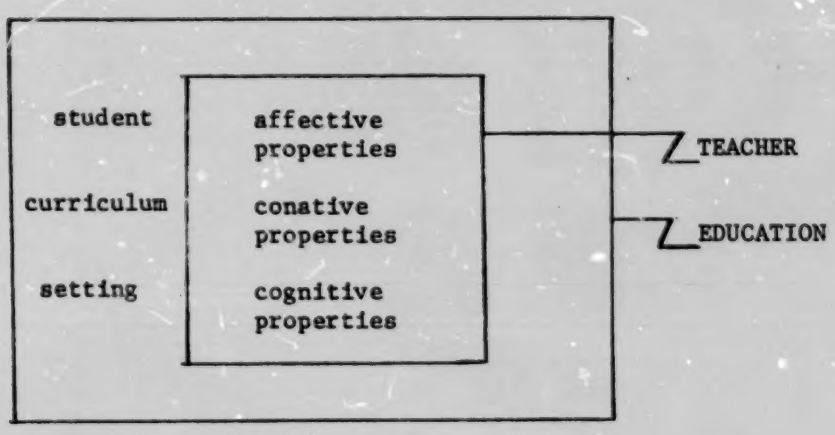
Figure 3: Education as a system

that what is taken as a component in one universe of discourse can be taken as a system in another. Changing the universe of discourse from

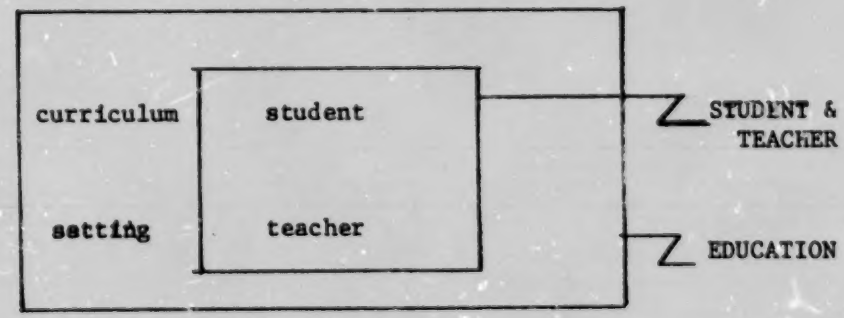
the state to education, the student can be taken as a system rather than as a component. One would then delineate the components within the student, i.e., the affective, conative, and cognitive properties. These properties would be the components of the system and the components other than the student would be those of the negasystem. Within education one is not limited to the student as system. The teacher or curriculum or setting or any combination of two or three components of education could be taken as the system. The negasystem would be changed accordingly. Figure 4 shows three different system perspectives within education.



Student as System



Teacher as System



Pedagogic System

Set theory not only gives precision to "complex of elements" but also to "standing in interaction." The precision is obtained by utilizing the set theoretic definitions of "function." Since a function from one set into another is constituted by an association of elements in one set with those in the other, standing in interaction can be interpreted as a mapping of the set into itself, and hence as affect relations. For example, the affect relations between the components of the educational system are constituted by the mapping of teacher, student, curriculum, and setting into teacher, student, curriculum, and setting. That is to say, where there is association between a teacher property and a student property, the teacher property affects the student property or the student property is a function of the teacher property.

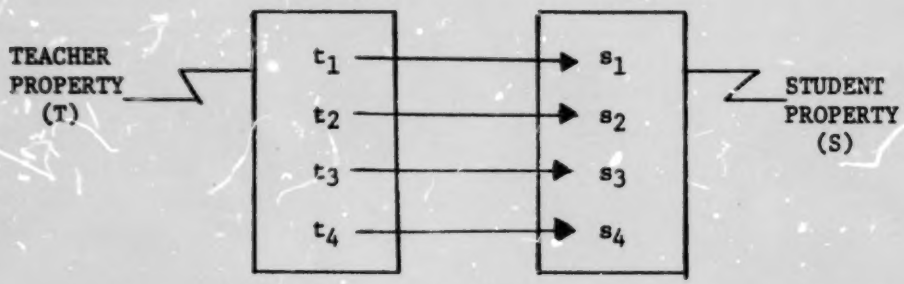


Figure 5: Function of teacher property to student property

$$f: \quad T \rightarrow S$$

where $S = \{t_1, t_2, t_3, t_4\}$

$S = \{s_1, s_2, s_3, s_4\}$

$f = \{(t_1,s_1), (t_2,s_2), (t_3,s_3), (t_4,s_4)\}$

Set theory is also utilized to give precision to conditions on the system over and above the essential ones treated above. It is used explicitly to give precision to system characteristics such as sameness within a system's structure. Such uniformity is set forth as an isomorphic mapping. An illustration in education would be uniformity in the curriculum. Set theory is used implicitly when information or graph theories are utilized for system characterization. This is so, because set theory is basic to both information theory and graph theory.

Digraph theory is mathematical theory which characterizes between pairs of points lines which can be directed. Figures can be utilized to explicate intuitively a digraph, as in Figure 6.

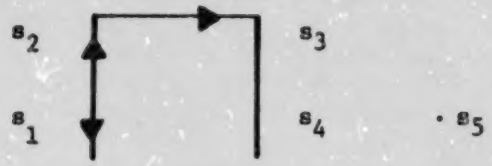


Figure 6

Figure 6 was constructed from points - s_1, s_2, s_3, s_4, s_5 - and lines, some of which are arrows. There are no lines between s_5 and the other points. Thus, s_5 is not connected to or paired with any of the other points. Where there is an arrow or arrows between two points, there is a directed connection or a pairing. Consequently, there is a directed connection or pairing between s_1 and s_2, s_1 and s_3, s_2 and s_1, and s_2 and s_3. Given only one arrow between two points, the directed connection is direct as in s_1 and s_2, s_2 and s_1, and s_2 and s_3. Where there is a line without an arrow, a directed connection will be assumed in one or the other direction or in both directions. The result of such an assumption is the treatment of graph theory within the context of digraph theory. "Di-" indicates that graphs consist of directed lines. Interchangeable usage of the terms, "graph theory" and "digraph theory," therefore, is permitted. So a directed connection is assumed between s_1 and s_4, s_2 and s_4, s_3 and s_4 or s_4 and s_3 or both. Since the line between s_2 and s_3 has an arrow, the direction is given from s_2 to s_3 and not from s_3 to s_2. Therefore, s_3 is not paired to s_2 or s_1 and also s_4 is not paired to s_2 or s_1. To summarize, the graph in Figure 6 can be expressed in a matrix.

	s_1	s_2	s_3	s_4	s_5
s_1	0	1	1	1	0
s_2	1	0	1	1	0
s_3	0	0	0	1*	0
s_4	0	0	1*	0	0
s_5	0	0	0	0	0

where "*" indicates the possiblity of one of the two entries being 0

and as a relation

$(s_1, s_2), (s_1, s_3), (s_1, s_4)$
$(s_2, s_1), (s_2, s_3), (s_2, s_4)$
$(s_3, s_4) \vee (s_4, s_3)$

From the matrix it can be seen that the total possible pairs of points in a graph of five points is twenty, and that the graph presented in Figure 6 has only seven or eight pairs out of the twenty.

By adding graph theory to set theory, the complex of elements which is a system is not only interpreted as a set but also as a set of points, and the standing in interaction which is a system is not only interpreted as functions but as directed lines. This added interpretation permits the utilization of properties of graphs to give precision to certain properties of systems. For example, a system would have complete connectedness if and only if all its affect relations were direct directed ones, i.e., direct channels from and to each component. The graph presented in Figure 6 is not completely connected. Rather it is disconnected. Figure 7 presents a completely connected graph.

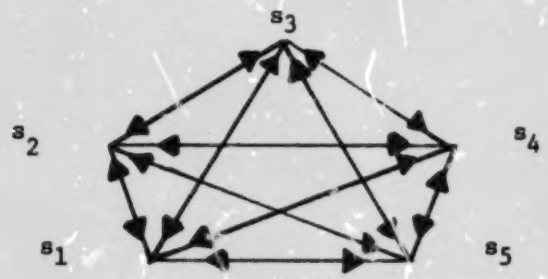


Figure 7

To illustrate the utilization of graph theoretic properties with respect to education, consider transmission of culture in a group consisting of a teacher and four students. Let the point s_5 represent the teacher, s_1, s_2, s_3, and s_4 the students, and lines between the points transmission channels. Figure 6, therefore, represents a system in which there is no connection between the teacher and any of the students. The teacher does transmit culture. However, each student is in the same position as the teacher in regard to the transmission of culture (Maccia, Note 1).

In order to treat transmission, information theory must be used as well as graph theory. Information is the characterization of occurrences. This fits in with the ordinary notions of information. When one is informed, one knows or can characterize what is happening. To characterize occurrences is to classify them according to categories. But for describing transmission the condition of selectivity must be placed upon information. There must be uncertainty of occurrences at the categories. Uncertainty of occurrences is explicated in terms of a probability distribution. In a system context, if there is uncertainty with respect to an occurrence of a system component at a category of a classification of the system components, then the probability at the category can be neither 1 or 0 but must be less than 1 or greater than 0. Consequently, there must be at least one alternative category for the occurrence of the component, since the sum of the probabilities must be equal to 1. Alternatives

indicate selection. This selective sense of information also fits in with the ordinary notions of information. One needs information only when one does not know something. We must be uncertain or faced with a choice between alternatives. Complete knowledge involves no uncertainty or no need for information.

The basic information function is designated by "H." By summing over the amount of information associated with each selection, weighted by the probability that the selection will occur, the value of H can be obtained. To state the matter more precisely, H(C) is the average uncertainty per occurrence with reference to the classification C; it is the average number of decisions needed to associate any one occurrence with some category c_i in C, with the provision that the decisions are appropriate; it is a function of the probability measures in C:

$$H(C) = \sum_{i=1}^{n} p(c_i) \log_2 \frac{1}{p(c_i)}$$

The measure for joint uncertainty would be:

$$H(C_{IJ}) = \sum_{i=1}^{m} \sum_{j=1}^{n} p(c_i, c_j) \log_2 \frac{1}{p(c_i, c_j)}$$

The measure for conditional uncertainty would be:

$$H(C_I|C_J) = \sum_{i=1}^{m} \sum_{j=1}^{n} p(c_i, c_j) \log_2 p(c_i|c_j)$$

The three H measures are related as follows:

$$H(C_I) + H(C_J|C_I) = H(C_{IJ})$$

The T measure is the amount of shared information:

$$T(C_I, C_J) = H(C_I) + H(C_J) - H(C_{IJ})$$

The following properties of a system can be interpreted in terms of H:

toput, TP, which is information of the system's surroundings (the negasystem) available to the system for its selection, i.e., the system's environment

input, IP, which is information of the system

storeput, SP, which is information of the system not available to its surroundings

fromput, FP, which is information of the system available to its surroundings

output, OP, which is information of the system's surroundings

The sharing of information, T, as well as being separated by time intervals gives meaning to the following system properties descriptive of information transmission:

feedin, FI, which is a transmission of information from the system's surroundings to the system

feedout, FO, which is a transmission of information from the system to its surroundings

feedthrough, FT, which is a transmission of information from a system's surroundings through the system back to its surroundings

feedback, FB, which is a transmission of information from the system through its surroundings back to the system

Figure 8 displays these information theoretic properties with respect to a student system.

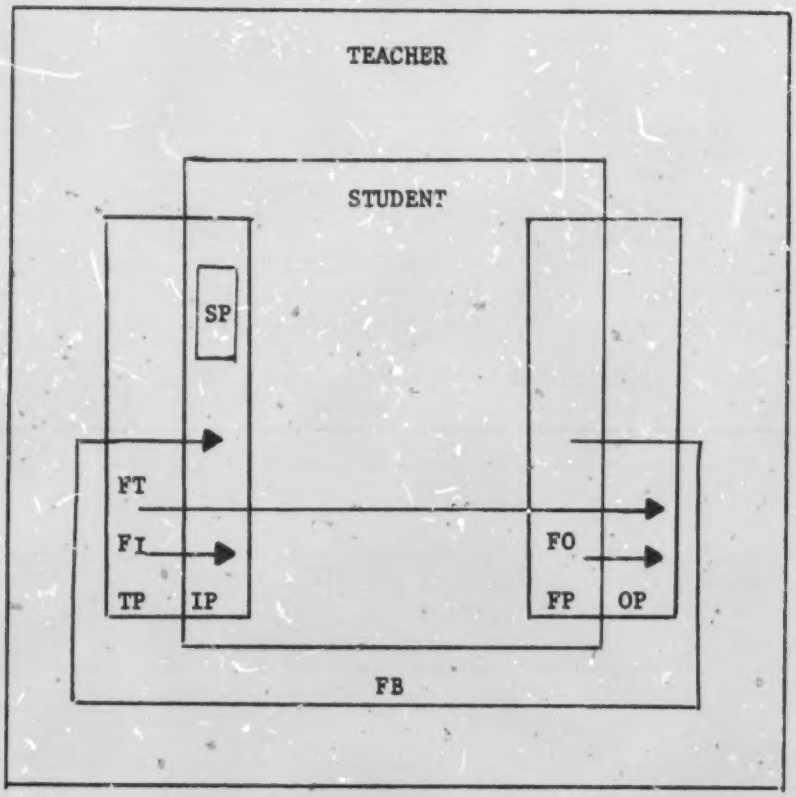


Figure 8: Information theoretic properties of a student system

In considering these information theoretic properties the extension of the cybernetic model through SIGGS should be noted (Maccia & Maccia 1975).

In the context of the non-extended cybernetic model shown in Figure 9,

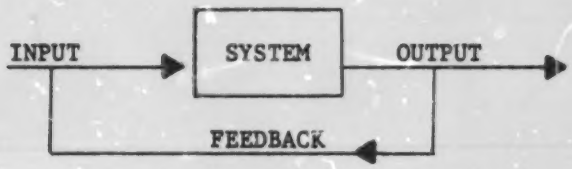


Figure 9

no descriptions of system-surroundings interactions are possible. Given SIGGS, toput and a new sense of output are added to input and output which is now interpreted as fromput. Determination is now possible not only of what the system takes in and what is available from it but also of what the system's surroundings take in and what is available to them. Feedin, feedthrough, and feedout are added to feedback which is now interpreted as flow from output to input. Transmission from and to both the system and its surroundings can be characterized.

Also these information theoretic properties should not be given a mechanistic interpretation. Input cannot be viewed as determining output, i.e., input and output viewed as a functional relation in which input is the independent variable and output is the dependent variable. The model of system shown in Figure 10

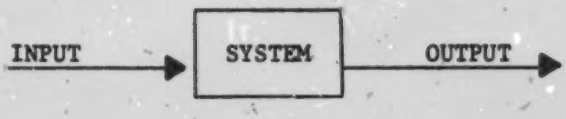


Figure 10

is mechanistic and inadequate. What is outputed or what the system is to do, its function, determines what is to be inputed or what the system is to be. Thus, this model's linearity and additivity must give way to the functionality of SIGGS (Maccia & Maccia, Note 2).

To illustrate the difference between a mechanistic interpretation and a general systems one, consider the following conceptualization relating the teacher as environment to the student as system:

		Student (S)					
		1	2	3	4	5	6
Teacher (T)	1						
	2						
	3						
	4						
	5						
	6						

In a mechanistic interpretation in which teacher action is taken as input causing the output student action, observed frequencies inserted in the above table would be in terms of some position, i.e., a precise location in a specified metric space. Each frequency of S or T would be taken as representing a unit of a line drawn in a certain direction in reference to other lines. An intersect of teacher action and learner action would be a unit of a line surface that bounds the metric space. To estimate the causal connection between the input and output, computation such as Chi square would be utilized. Chi square computations compare the line surface given by mapping the observed distribution with the line surface generated by some expected distribution, i.e., random, Poisson, or another appropriate distribution.

In a general systems interpretation, the observed frequencies would be in terms of the joint occurrence of teacher action and student action where such actions are not taken as input causing output. The teacher action would not be viewed as input but as toput or information available to the student for selection. The student action would not be viewed as output but as input or information selected by the student from the toput. Estimation of the relation between toput and input would be made without reference to line surfaces taken as normal or appropriate. It would be made through a measure of the transmission of information, i.e., the information shared between the teacher and student, T(T,S), which is calculated as follows:

$$T(T,S) = H(T) + H(S) - H(T,S)$$

where $H(T)$ is the amount of information in teacher action

$H(S)$ is the amount of information in student action

$H(T,S)$ is the amount of information in teacher and student actions taken jointly

Obviously transmission is not taken in a directional sense. The general systems interpretation is geometric rather than arithmetic. Interactions are taken as changes in patterns. The whole or the configuration is taken as the reality to be described.

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APPLICATION OF SIGGS TO PROJECT PRIME

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Extant educational research has revealed little reliable, scientific knowledge of the teaching-learning process (Mood, 1970; Smith, 1971; Rosenshine, 1971; Soar, 1972; Rosenshine & Furst, 1973; Heath & Neilson, 1974; Dunkin & Biddle, 1974). It is patent, however, that teachers have come to know about education through observation of and participation in the teaching-learning process. It is also evident that such individuals may be skillful teachers, but may not be knowledgeable about education. That is, a teacher can be effective in producing student learning, yet not be able to explain why.

While it appears that scientific knowledge of the teaching-learning process lacks general predictive or explanatory power, it is not implied that philosophical knowledge of education is lacking (Dewey, 1916). Nor is it implied that praxeological knowledge of education is necessarily deficient. In short, there does not exist currently a well-defined valid body of quantitative knowledge which constitutes a science of education.

Perhaps our models for conceptualizing educational research are in need of modification.

The Use of Theory Models In Research

The complete act of inquiry involves retroduction, deduction, and induction (Dewey, 1916; Pierce, 1958; E. S. Maccia, 1963). The notion of retroduction was formally introduced by Pierce in the twentieth century, while deduction and induction are much older concepts.

Deduction is usually associated with rules of conceptualization. Formal logic is the basis of deriving specific hypotheses from more general theorems or postulates in deduction. Induction is just the converse--going from the specific to the general. Rules of induction are usually taken as rules for verification. These are commonly known as statistical rules of inference for comparing specific states of affairs to hypotheses.

Retroduction is taken to mean the use of models for conceptualizing or theorizing. Retroduction is referred to as the "theory models approach" (E. S. Maccì, G. S. Maccia, & Jewett, 1963). In contradistinction, a theory is a model of reality. When one theory is used as a model to generate another theory, the former (Theory A) serves as a theory model (analogy) for the latter (Theory B). For example, quantum physics theory (A) can be used to generate an all-or-none learning theory (B). Retroduction is in contradistinction to reduction in that Theory B is not reducible to Theory A. Retroduction differs also from deduction in that Theory B is not completely deducible from Theory A. Rather, through retroduction Theory A becomes a model for some, but not all, of Theory B.

Thomas S. Kuhn, in the Structure of Scientific Revolutions (1970), demonstrates the power of paradigms (methodologies, meta-models) in influencing the nature of scientific inquiry throughout the history of science. Jacob Bronowski, in The Ascent of Man (1973), also emphasizes the power of models for conceptualizing problems in research. Both Bronowski and Kuhn use the example of Copernicus to demonstrate the gripping influence of older paradigms in preventing newer and more adequate paradigms from being adopted. Astronomers in the Ptolemaic (older) paradigm viewed the earth as the center of the revolving heavens, whereas the Copernican paradigm stipulated that the sun was the center of the solar system and the earth was one of several planets which revolved in orbits around the sun. According to Bronowski, the word "revolution" took on its additional meaning because of the revolutionary ideas of Copernicus. Unfortunately it is often the case that newer paradigms, even while more adequate, are usually not adopted by a field of scientific inquiry until the leading proponents of the older paradigms literally die off (Kuhn, 1970).

In the field of human sciences an organismic paradigm is emerging to supplant a mechanistic view of human being (C. W. Churchman, 1968; von Bertalanffy, 1968; Ackoff & Emery, 1972; Banathy, 1973; Miller, 1974; E. S. & G. S. Maccia, 1976). The organismic view is not new. Some relatively recent manifestations of this view in education-related fields are found in the Gestalt view of psychology at the turn of this century, Dewey's philosophy of functionalism, and most recently, general systems theory.

Ludwig von Bertalanffy (1955, 1968) is given credit for first proposing a general systems theory. It is important to note the difference between general systems, specific systems, and mechanistic systems. General systems is a holistic, or an organismic perspective. The whole is seen as determining relations among parts (components) which comprise a system. In a strictly mechanistic (atomistic) view, parts are viewed in isolation rather than in complex relation and are seen as additive, or summing to form a whole. In a general systems view, the whole is said to be greater than the sum of its parts. In this perspective a system is also viewed in mutual or complementary relation to its surroundings, or environment. Not only can the environment influence the system but also the system can influence the environment.

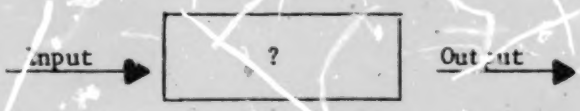
General systems have properties over and above specific systems such as closed systems, nervous systems, air-conditioning systems, biological systems, ecological systems, and so on. Ludwig von Bertalanffy (1968) asserted that there are isomorphisms across many different disciplines or fields of inquiry, as in physics, anatomy, and sociology. That is, there are general properties of systems which are inclusive of all specific systems. He envisioned a unification of science through general systems theory. General systems theory could be used as a model or paradigm for investigation in all fields of science, especially in fields where the science is relatively undeveloped and theory is not well-defined. The isomorphisms in general systems theory could be used as models for theorizing in such an immature science. The science of education seems a likely candidate for the use of general systems theory.

Evolution of Systems Models in Educational Research

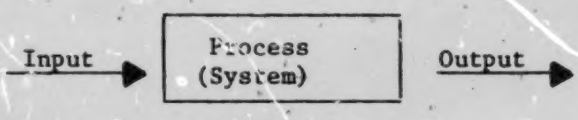
The use of the systems approach in educational inquiry is not new. A caveat is offered, however: the systems approaches used are often not in the spirit of general systems theory. Hence, we can easily become confused when we read studies which apply superficially the systems terminology, and yet, in actuality, are conceived and interpreted in a quite mechanistic (non-organismic) manner. The statistical models used in most extant educational research support a mechanistic view, such as linear models, additive models, and assumptions of independence of observations.

Four types of systems models and exemplary education research, if extant, will be discussed: input→output, input→process→product, cybernetic (closed-loop feed-back), and general systems models. It will be seen that each model is successively inclusive of the previous one(s).

Schema 1.1 Input→Output Model



Schema 1.2. Input→Process→Output Model



Schema 1.3. Cybernetic (Feedback) Model

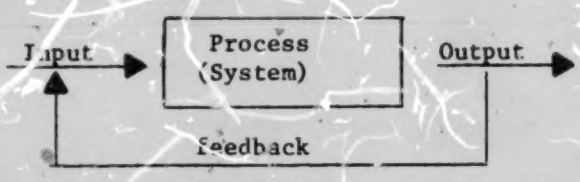


Figure 1. Types of system models

Input→output model. In this model what comes out of a system (output) is viewed in terms of what goes into the system (input), with no direct concern as to what goes on within the system. The system is taken as a black box. (See Schema 1.1). The Coleman report on Equality of Educational Opportunity (1966) exemplifies this input→output model. Input variables such as learner sex, socioeconomic status (SES), race, and teacher verbal ability were used to predict learner academic achievement as an output variable. Guthrie (1970) has also reviewed 18 other

major studies in which various school inputs have been investigated in an attempt to predict learner academic achievement as the primary school output.

Input→process→output model. In educational research this model is sometimes termed "Input→Process→Product" or "Presage→Process→Product" (Semmel, 1974; Dunkin & Biddle, 1974). The black box (the system) is included in this model in characterizing the teaching-learning process. It can be seen (Schema 1.2.) that the input→output model is contained in the input→process→output model. Process characterizations are usually obtained through systematic observation of classroom (Medley & Mitzel, 1963; Flanders, 1970; Simon & Boyer, 1974; Semmel, 1974). In this model, input and/or process variables are used to predict output (product) variables. A recent example of the application of this model was Project PRIME (Kaufman, Semmel & Agard, 1973). The major purpose of the study was to determine for whom and under what conditions mainstreaming of mildly handicapped pupils is a viable educational alternative. Some of the input variables were learner socioeconomic status, ethnic background, sex, and handicapping conditions. Process variables included classroom observation of pupil participation, learner on-and-off-task behavior, teacher management behavior and questioning styles, and classroom climate measures. Examples of product variables were learner academic achievement, teacher ratings of pupils, learner social status in the classroom, and learner attitudes and feelings about school.

An assumption underlying these two models is that input and/or process variables influence output variables. What is usually neglected, however, is the simultaneous influence of output variables on input and/or process variables (Levin, 1970). For example, the influence of learner attitude on academic achievement is investigated without simultaneously accounting for the influence of academic achievement on attitude. What is lacking is a feedback relation.

Cybernetic (closed-loop feedback) model. This model is a further extension of the input→process→output model in that output can be viewed as regulating input. (See Schema 1.3). The system is said to be self-regulating, cybernetic, or homostatic (Cannon, 1932; Wiener, 1948). In education, a clear example of utilization of this model is the Computer-Assisted Teacher Training System (CATTS) (Semmel, 1968; Semmel, Olson, & Weiske, 1972; Semmel & Frick, 1975). CATTS is an application of computer technology in assessing teacher/learner performance through systematic observation. The technology allows immediate feedback of results so that a teacher can regulate his/her teaching behavior in accordance with pre-established teaching objectives.

General systems models. The general systems model is a further extension of the cybernetic model (von Bertalanffy, 1968; Miller, 1974). The general systems model is portrayed in Figure 2. It can be seen that the system is viewed in interaction with its environment or surroundings. The environment can modify the system, as well as the system can affect the environment; hence, the addition of throughput (feedthrough, flow-through) to the cybernetic model. Whereas in the cybernetic model output was viewed as directly affecting input (closed-loop feedback), in the

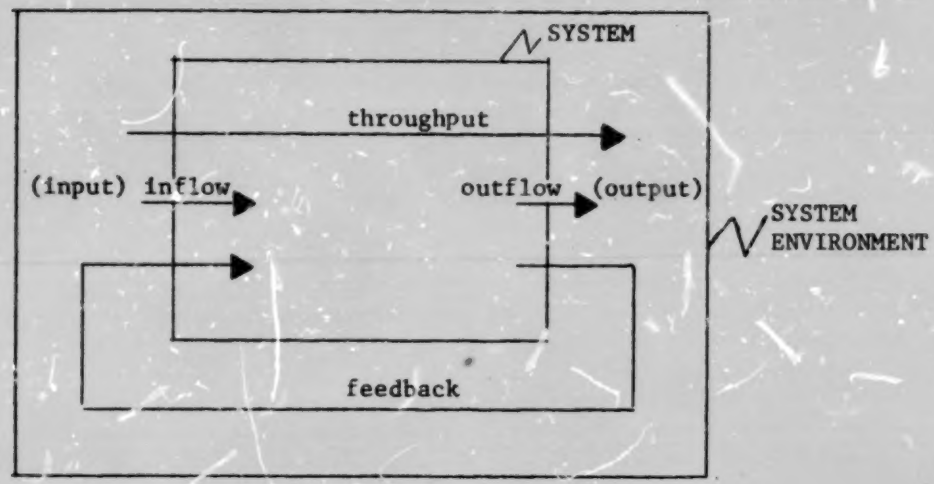


Figure 2. General Systems Model

general systems view feedback is seen as going <u>through</u> the environment and back to the system. That is, the environment can act on the system, as well as the system on the environment. There is complementarity or reciprocality between system and environment.

In an education system these would be called transactional teacher-learner systems, if the teacher is the system of focus and the learner is the teacher's environment (Maccia and Maccia, 1975). The difference is subtle, but significant. A cybernetic model would view the teacher as <u>the</u> agent of influence, whereas the general systems model views the teacher and learner <u>both</u> as mutual agents of influence. Hence, we consider not only the effects of the teacher on the learner, but also the effects of the learner on the teacher. That is, we truly look at teacher-learner <u>interaction</u>. If the <u>teacher</u> is the system of focus and the <u>learner</u> is part of the <u>teacher's</u> environment, the latter is feedthrough (environment → system → environment), and the former is feedback (system → environment → system).

There are few examples of utilization of <u>general</u> systems models in educational research. The beginning of such research is found in works by Banathy (1973; 1975), Semmel & Frick (1975), Ames (1975), and E. S. & G. S. Maccia (1966, 1969, 1975, 1976). Applications of general systems models to research and/or development are more readily found outside education by such authors as Ackoff, Ashby, Churchman, Emery, Mesarovic, Rappoport, and von Bertalanffy.

Mathematical Characterization of Systems

Much of extant educational research has been organized under the mechanistic (atomistic) model. Most statistical textbooks in the behavior sciences start with assumptions for a linear, additive model (Kirk, 1968; Hays, 1973; Kerlinger & Pedhauzer, 1973). While good statisticians warn the researcher to not apply this linear, additive model to research data when such a model is not appropriate for characterizing types of relations suggested by the theory or questions of interest, we often forget or ignore this advice (Coombs, 1960; Kaplan, 1964).

In analysis of variance, or more generally, the structural equation approach, multiple regression, path, cannonical, factor, and discriminate analyses, deviations from the regression line or curve are viewed as errors of measurement and/or residual errors. If such a model is used, then it is implicit in the theory to be verified that if all measurement errors were eliminated, and if all confounding effects were controlled, then each data point in a dimensional space would ideally fall on the line (curve) predicted by the equation. But many of us have forgotten that the mathematical function for a line is an <u>imposition</u> on the data. Such an imposition of function is not necessary for characterizing a mathematical relation among two or more variables. T-measures in information theory make no such imposition, for example.

The <u>same</u> data points, expressed in a Cartesian coordinate system, are given. Notice the differences in imposition of functions. In Figure 3, we speak of deviations of points (residual error from an ideal, continuous function which is expressed as a equation for a straight line.

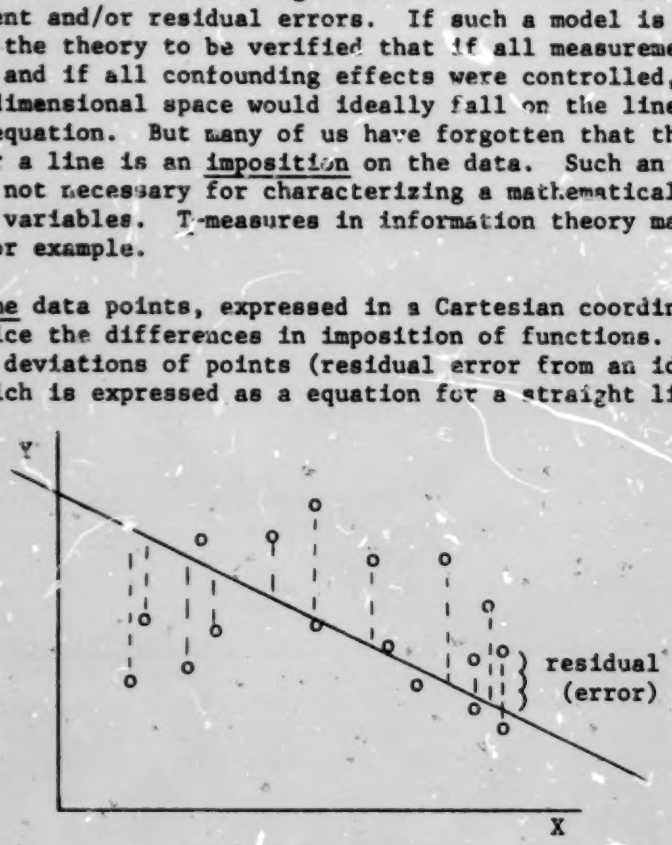


Figure 3. Residual Errors in an XY Plot from a Single Linear Function

But why impose a straight line? Why not a complex squiggly line as in Figure 4?

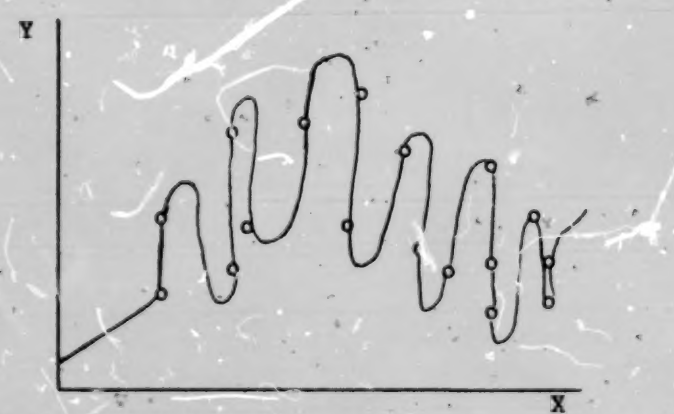


Figure 4. No Residual Errors by Using a Complex Linear Function to Characterize the Same Data as in Figure 3

Why impose any function? Why not view the relation as the uncertainty of the joint occurrence of discrete regions of variable X and Y?

No function is imposed in Figure 5. The relation of X and Y is

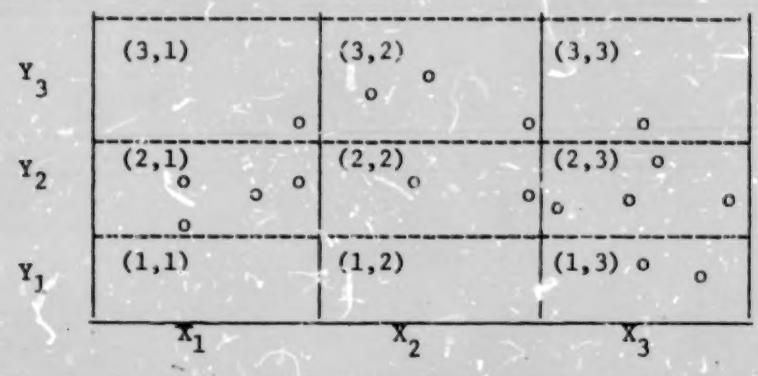


Figure 5. Characterization of Same Data as in Figure 3 in Terms of Uncertainty Using Mutually Exclusive and Exhaustive Categories (Intervals, Regions)

expressed in terms of probabilities of the joint occurrences of one discrete region (category, interval) and another. Moreover, the theory of interest dictates what these categories are; that is, the boundaries among categories. In order to do this, the categories of variable X must be mutually exclusive and exhaustive of all possible occurrences of variable classification X--likewise for Y. These assumptions are necessary to meet the basic tenets of probability theory and information theory. Notice, however, we have made no assumptions of linearity or additivity among variables. We are not imposing any mathematical equation (a straight or curved line) from which deviations of data are considered as errors of one type or another. We are simply characterizing the uncertainty of the relation without imposing any mathematical function.

The point of this discussion is to sensitize the reader that if we change our theory model (to a general systems model), then we must be careful of blindly applying traditional statistical procedures to new theories under the new paradigm. This is particularly true if it is believed that the linear, additive assumptions are unwarranted for complex organismic relations.

Further explication of information statistics is given in a later section of this paper.

Summary

Varying degrees of utilization of systems models for conceptualizing educational research have been discussed. It is apparent that general systems models are inclusive of input → output, input → process → product, and cybernetic (closed-loop feedback) models. It was emphasized that general systems is an organismic view in contradistinction to a mechanistic (atomistic) view. In the organismic view, the whole is taken to

determine relations among the parts, and is, in a sense, greater than the sum of the parts. In addition, the system is viewed in mutual relation to the system environment. It was then asserted that traditional statistical procedures may need modification to characterize adequately complex relations among parts of systems, and system-type environment interactions.

Explication of the SIGGS Theory Model

The SIGGS theory model (Set, Information, Graph, and General Systems Theory Model, Maccia and Maccia, 1966) is an extension of general systems theory. A general systems model is inclusive of specific or limited systems models. SIGGS is a further extension of general systems in that Set theory, Information theory, and di-Graph theory are used as models to extend General Systems theory. Set and digraph theory are mathematical theories, whereas information theory derives from communications engineering (Shannon & Weaver, 1949); and, of course, Ludwig von Bertalanffy (1955) is credited for general systems theory. The relationships among these four theory models, SIGGS, and education inquiry are depicted in Figure 6.

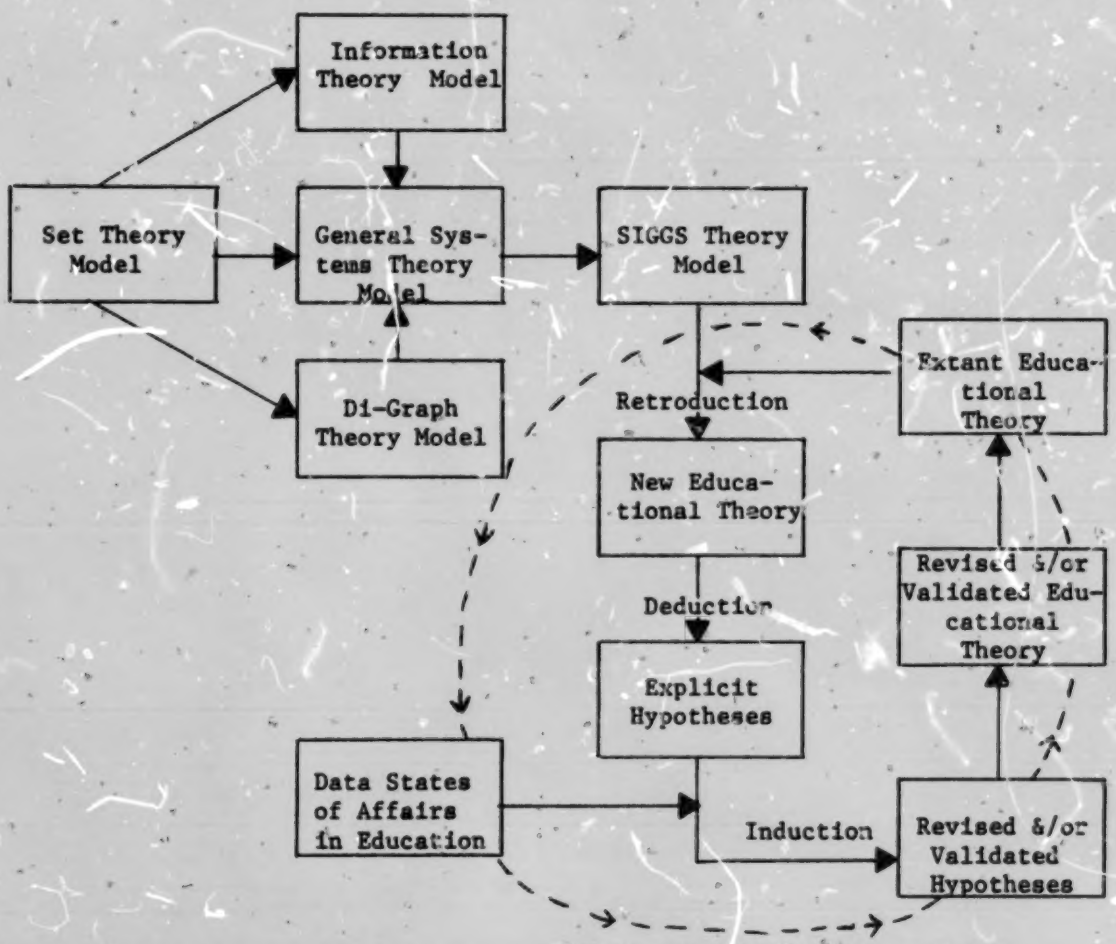


Figure 6. Relationship of SIGGS to Other Theories

The schema in Figure 7 and Tables 1 and 2 illustrate the derivation of SIGGS from primitive terms. Primitive terms are necessary in any definitional system to prevent circularity. Given the primitive terms, "universe of discourse," "component," "characterization," "condition," and "value," indirect and direct SIGGS characterizations evolve in the order indicated by the numbers in Tables 1 and 2. Higher-order SIGGS characterizations are defined in terms of lower-order characterizations and ultimately in primitive terms. Whenever necessary, set-theoretic, information-theoretic, and graph-theoretic terms are employed, each of which is ultimately derived from its respective primitive terms. Thus, SIGGS meets the requirements of a formal definitional system.

A system is defined in natural language as "a group of at least two components with at least one affect relation and with information" (Maccia & Maccia, 1966, p. 95). To illustrate the precision and clarity of the formal definition of a system the following is the predicate calculi used for logical definition:

> ['System,' S] equals by definition ['group, S, such that there is a family of affect relations, R_A, such that R_A is not equal to the null set, $\emptyset$] [and for all affect relations, R_A, R_A is an element of R_A, only if R_A is contained in the Cartesian product of S and S,] [and there is a family of informations, I, such that I is not equal to $\emptyset$,] and for all information, I, I is an element of I only if either (I is equivalent to R_A) (or there is a family of affect relations, R, such that R is contained in the power set of R_A and I is equivalent to R) (or there is a group, S', such that S' is contained in S and I is equivalent to S' and I is not equivalent to any combination thereof')] (Maccia & Maccia,1966, p. 45)[1].

Each of the terms used in the definition of a system was previously defined. The term, "information," was, for example, previously defined in natural language as a "characterization of occurrences" (Maccia & Maccia, 1966, p. 40). Ultimately, every term in the formal definition of a system can be traced to the set of primitive terms stated in Figure 7. Thus, it can be seen that SIGGS characterizations are given meaning from set-, information-, di-graph-, and general systems- theoretic characterizations. SIGGS characterizations are given further meaning in the teaching-learning process when used as a model for retroduction of new educational theory. (See Schema in Figure 6).

The key terms in the definition of a system are "group," "affect relation," and "information." Each of these terms will be discussed briefly.

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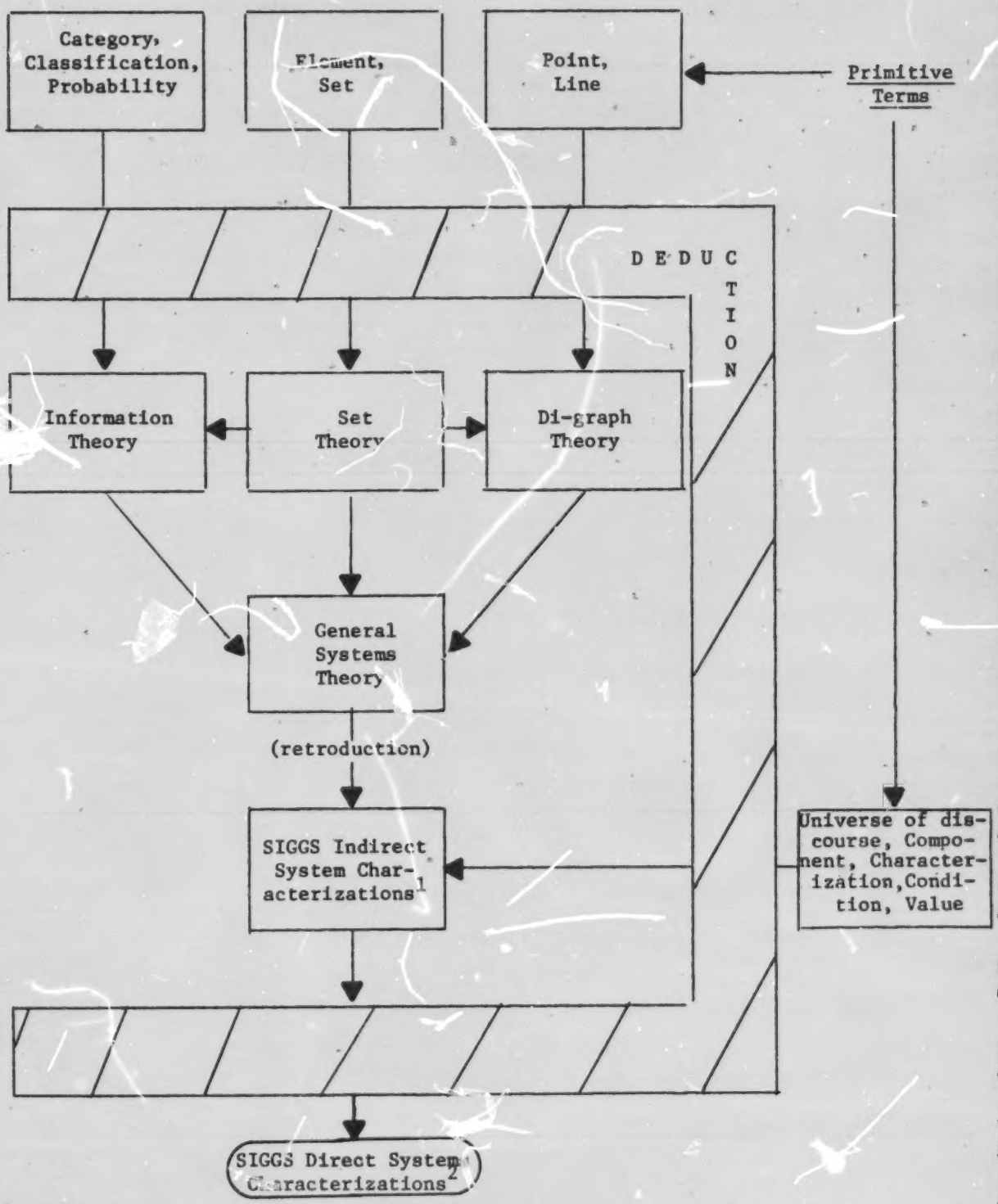
[1]Brackets, [] , and parentheses, (), were added to help organize the parts of the definition for the reader. Hereafter, only natural language definitions of terms will be given, since it is assumed that most readers will not understand the predicate calculi. It should be pointed out, however, that it is just those calculi which allowed such precise extension of general systems theory.



1 See Table 1.
2 See Table 2.

Figure 7. Illustration of SIGGS Derivation

Table 1. SIGGS Indirect System Characterizations*

1. Group

2. Information

   2.1. Selective Information

      2.1.1. Non-conditional Selective information
      2.1.2. Conditional Selective information

3. Transmission of Selective Information

4. Affect Relation

   4.1. Directed Affect Relation

      4.1.1. Direct Directed Affect Relation
      4.1.2. Indirect Directed Affect Relation

6. Negasystem

8. Negasystem State

10. Negasystem Property

12. Negasystem Property State

14. Negasystem Environmentness**

16. Negasystem Environmental Changeness

19. Fromputness

20. Outputness

*Taken from Maccia & Maccia (1966), p. 68.
**14, 16, 19, and 20 are negasystem properties.

Table 2. SIGGS Direct System Characterizations*

Non-Properties

5. System
7. System State
9. System Property
11. System Property State

Properties

13. System Environmentness
15. System Environmental Changeness
17. Toputness
18. Inputness
19. Storeputness
20. Feedinness
21. Feedoutness
22. Feedthroughness
23. Feedbackness
24. Filtrationness
25. Spillageness
26. Regulationness
27. Compatibleness
28. Openness
29. Adaptiveness
30. Efficientness
31. Complete Connectionness
32. Strongness
33. Unilateralness
34. Weakness
35. Disconnectionness
36. Vulnerableness
37. Passive Dependentness
38. Active Dependentness
39. Independentness
40. Segregationness
41. Interdependentness
42. Wholeness
43. Integrationness
44. Hierarchically Orderness
45. Flexibleness
46. Homomorphismness
47. Isomorphismness
48. Automorphismness
49. Compactness
50. Centralness
51. Sizeness
52. Complexness
53. Selective Informationness
54. Size Growthness
55. Complexity Growthness
56. Selective Information Growthness
57. Size Degenerationness
58. Complexity Degenerationness
59. Selective Information Degenerationness
60. Stableness
61. State Steadiness
62. State Determinationness
63. Equifinalness
64. Homeostasisness
65. Stressness
66. Strainness

*Taken from Maccia and Maccia (1966), p. 69.

Group. The characterization, "group," is akin to set in set theory in which the components of the groups are like the elements of a set; and there are at least two components which comprise the group. Moreover, the group must be a subset of the universe of discourse. Universe of discourse, component, and characterization are primitive (undefined) terms. Boundaries of the system are defined by the set-theoretic characterization, "complement." That is, those components in the universe of discourse not taken to be in the group (which is the system) comprise the negasystem (literally, not-system).[2]

The group has conditions on it over and above that of a set of two or more components which form a unit in the universe of discourse. The group must have at least one affect relation which has information in order for the group to be a system.

Information. "Information" is taken as a characterization of occurrences. Like elements which are members of a set, categories are members of a classification. Moreover, the categories must be mutually exclusive and exhaustive of the classification. That is, every occurrence of a system component can be characterized by one and only one category in a classification, and all component occurrences can be characterized by the classification. These conditions on the characterizations allow the assignment of a probability to each category in the classification, and the probabilities of all categories sum to unity.

The added condition of "selectivity" to information means that there is uncertainty with respect to occurrences at the categories in a classification. Thus, at least one category has an associated probability of occurrence which is greater than zero and less than unity. Therefore, there must be at least one other category which also has a non-zero, non-unity probability of occurrence. In this sense, selective information is synonymous with uncertainty of component occurrences.

Affect Relation. A system is defined as a group with at least one affect relation with information. The term, "affect relation," is defined as "a connection of one or more components to one or more other components" (Maccia & Maccia, 1966, p. 42). An affect relation is likened to mapping of the group onto itself in set theory--a Cartesian product of the group (set) onto itself, such that a component (element) cannot occur with itself in any given ordered pair of components. Digraph theory adds further meaning by the notion of directed lines connecting points in space. The directed lines indicate the channels between components and the sequence of connections among components (which are akin to points).

Information can be used to characterize component occurrences, or affect relations among components, or both. The added consideration of time of occurrence of components allows characterization of flow within and across system boundaries.

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[2]Do not confuse negasystem with "system environmentness" which is "toputness." "System environmentness" has conditions on it over and above those of the negasystem.

Availability. Finally, the consideration of availability of the negasystem to the system (or conversely) sets off those components in the negasystem which are available to the system from those which are not. Those negasystem components which are available to the system are defined as "system environmentness". Likewise, those system components which are available to the negasystem are defined as "negasystem environmentness." These considerations allow distinctions among toputness, inputness, fromputness, outputness, and storeputness. The additional consideration of time allows definition of flows within and across system boundaries (feedinness, feedoutness, feedbackness, feedthroughness). See Schema in Figure 8 and Tables 3 and 4[3].

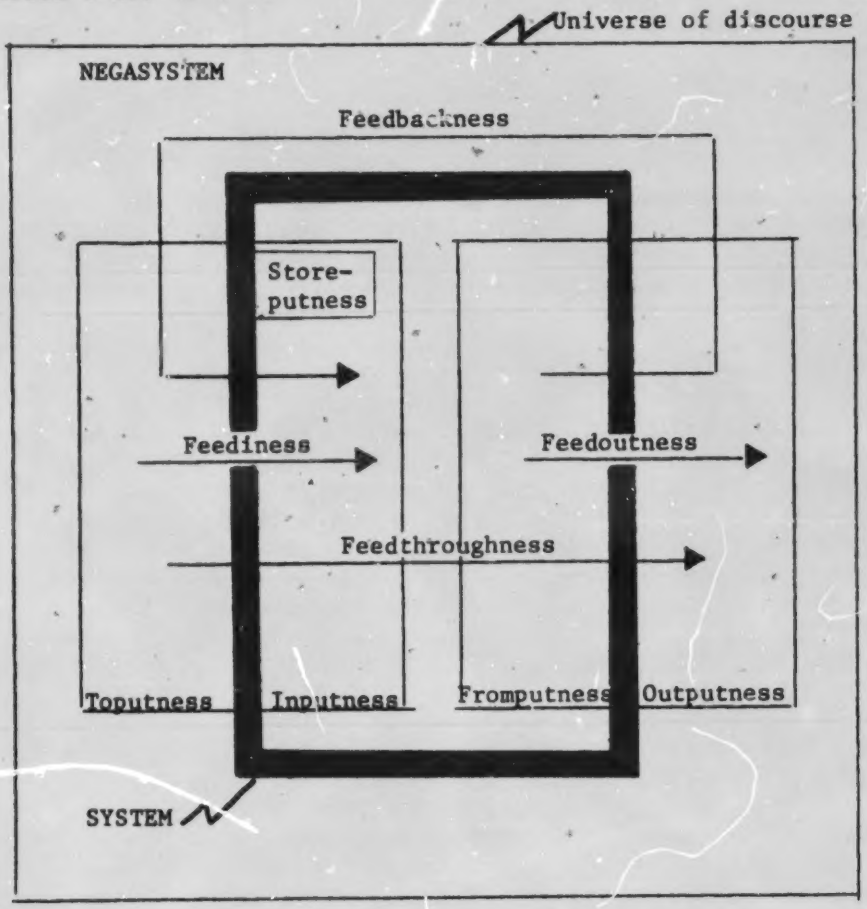

Figure 8. Information Properties of a System*
*Taken from Maccia & Maccia (1966), p. 99.

[3]The interested reader is referred to Atteneave (1959), Maccia, Maccia, & Jewett (1963), and Coombs, et al(1970) for additional insight into set, information, and digraph theory. For complete explication of SIGGS, see Maccia & Maccia (1966).

Table 3. Natural Language Definitions of Basic SIGGS System and Negasystem Characterizations.*

1. Universe of discourse (primitive)
2. Component (primitive)
3. Group: at least two components that form a unit (set) with the universe of discourse
4. Characterization (primitive)
5. Information: characterization of occurrences
6. Selective information: information which has alternatives
7. Transmission of selective information: a flow of selective information (in time)
8. Affect relation: a connection of one or more components to one or more other components
9. System: a group with at least one affect relation which has information
10. Negasystem: components not taken to be in the system (but in the universe of discourse)
11. System environmentness: a negasystem of at least two components, with at least one affect relation which has selective information
12. Negasystem environmentness: a system with selective information
13. Toputness: system environmentness
14. Inputness: a system with selective information
15. Fromputness: negasystem environmentness
16. Outputness: a negasystem with selective information
17. Storeputness: a system with inputness that is not fromputness (i.e., not available to negasystem)

*These natural language definitions are taken directly from Maccia & Maccia (1966, pp. 40-52). Note that these definitions are not as precise as the formal ones using predicate calculi.

Table 4. Natural Language Definitions of SIGGS System/ Negasystem Flows*

1. Feedinness: transmission of selective information from a negasystem to a system (between toputness and inputness when toputness occurs at a time just prior to inputness).*

2. Feedoutness: transmission of selective information from a system to a negasystem (between fromputness and outputness when fromputness occurs at a time just prior to outputness).*

3. Feedthroughness: transmission of selective information from a negasystem through a system to a negasystem (between toputness, inputness, fromputness, and outputness, respectively, when toputness occurs at a time just prior to inputness, inputness occurs prior to fromputness, and fromputness occurs prior to outputness).*

4. Feedbackness: transmission of selective information from a system through a negasystem to a system (between fromputness, outputness, toputness, and inputness, respectively, when fromputness occurs at a time just prior to outputness, outputness occurs prior to toputness, and toputness occurs prior to inputness).*

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*Note that 'feedinness' and 'feedoutness' are similar to ordinary notions of input and output. However, 'inputness' and 'outputness' take on special meaning here, and are not equivalent to ordinary meanings of input and output (See Table 3).

The reader will note that the information properties of a system, illustrated in Figure 8 are only but a few of the many system properties listed in Table 2. Thus, hypotheses about interrelationships among components of a system can be entertained and tested in the more comprehensive terms of system properties in Table 2. For example, not only can the function of shared information between presage (toputness) and product (outputness) variables be estimated across time (feedthroughness), but also dynamic constructs such as efficientness, stressness, integrationness, compatibleness, etc., can be entertained as well within hypotheses.

In short, extant theory about the teaching-learning process is extended when viewed in a SIGGS (extended general systems) framework. While only an introduction to SIGGS is intended here, already it can be seen how SIGGS adds clarity, precision, and completeness to extant conceptual models (paradigms) and/or theories in education (see Schemas 1.1, 1.2, 1.3, Figures 2 & 8). The further power and utility of SIGGS is demonstrated by framing one of the observation instruments (Indiana Behavior Management System--II, Fink & Semmel, 1971) used in Project PRIME in the context of a power theory set forth by French and Raven (1959).

Application of SIGGS to Project PRIME

Project PRIME (Programmed Re-entry Into Mainstream Education) is a large scale descriptive-correlational study. The major question addressed in the study, is, "For whom and under what conditions is mainstreaming of mildly handicapped children a viable educational alternative?" Mainstreaming refers to integration of mildly handicapped children into regular classroom settings on at least a part-time basis--which is in contradistinction to the traditional administrative arrangement of placing handicapped children in completely self-contained (special education) classes. In Project PRIME, data were collected on more than 2200 selected educable mentally retarded (MR), learning disabled (LD), and normal contrast (NC) children, on over 12,000 of their classmates, and on approximately 1300 teachers in 650 special education resources, and third-, fourth-, and fifth-grade regular classrooms located in 150 schools in 43 school districts throughout the state of Texas. A normal contrast child was a randomly selected regular classmate of a mainstreamed handicapped child. Data on each selected child were obtained from 28 different instruments, including standardized achievement tests, rating scales, observation systems, questionnaires, and sociometric, attitudinal, and self-concept scales. Sources of data included the selected child him/herself, his/her teacher(s) and peers, trained observers, principals, special education directors, and school superintendents.

The following example represents a <u>potentially</u> fruitful and somewhat unique attempt to utilize the general systems paradigm for <u>framing</u> educational research questions, and a utilization of information theory for analytic procedures. The example is viewed not as a final product, but rather as an initial endeavor.

IBMS in Relation to a Theory of Power

The Indiana Behavior Management System--II (Fink & Sechmel, 1971) is a PRIME observation system designed for recording simultaneously at ten-second intervals learner on- or off-task behavior, and teacher task or management of off-task learner behavior. Learner off-task behavior is considered as socially deviant behavior, whereas on-task means that the learner is attending to the task expected of him/her by the teacher. Teacher on-task means that the teacher is teaching (attending to instructional tasks), and teacher control is taken as social management of off-task learner behavior. It is patent that the purpose of teacher social management is to bring the learner back to task or to socially acceptable behavior. (See Table 5).

Since the focus of IBMS is primarily on learner off-task and teacher control behavior, a theory of influence (power or leadership) is implicit. Six types of influence have been posited by French and Raven (1959)[5]: reward, coercive, legitimate, expert, referent, and informational. In Table 5 it can be seen how the 13 IBMS teacher categories are grouped by the present author into the six influence categories. We will assume that these categories are mutually exclusive and exhaustive of the classification called teacher influence attempts. That is, every occurrence of a teacher attempting to influence a learner can be characterized by one and only one of the six influence categories. Moreover, the nine IBMS learner categories have been grouped (in Table 5) into three mutually exclusive and exhaustive categories used by Raven and Kruglanski (Horney, 1965) to characterize the effect of the influence attempt. They are moving toward, moving away, and moving against the influence attempt (in this case, the teacher's expectations of appropriate learner task or social behavior and/or attitudes). A brief discussion follows of these categories of teacher influence attempts and influence effects on the learner.

Teacher reward power. The teacher attempts to influence the learner by the use of rewards, such as praise, tokens, good grades, prizes, and extra privileges. The only IBMS category of this type is 'positive consequences,' in which the teacher promises the learner that something desirable (valuable) to the learner will happen as a consequence of the learner's actions in the appropriate direction.

Teacher coercive power. The teacher attempts to influence the learner by coercion, such as punishment, threats, and physical force. Three IBMS categories are of this type: negative consequences, punishment, and criticism-demeaning. 'Negative consequences' are threats of consequences undesirable to the learner if the learner does not act appropriately.

[5]Other sources (E. S. Maccia, 1963; Cartwright, 1965; Raven, 1965, 1973; Collins & Raven, 1969; Raven & Kruglanski, 1970; Safter, 1975) were utilized in part, but will not be directly cited in the following explication.

Table 5. IBMS Categories and Categories of Influence Attempts and Effects

IBMS Teacher Categories		Influence Attempt (IA_T)
1.	Task	Expert (Ex)
2.	Control (Management)	---
2.1	Redirection	Expert (Ex)
2.2	Positive Consequence	Reward (Rw)
2.3	Negative Consequence	Coercive (Co)
2.4	Punishment	Coercive (Co)
2.5	Criticism-Demeaning	Coercive (Co)
2.6	Demand	Legitimate (Lg)
2.7	Conditioned-Stimulus	Legitimate (Lg)
2.8	Value Law	Legitimate (Lg)
2.9	Empathic-Sympathetic	Referent (Rf)
2.10	Humor	Referent (Rf)
2.11	Interpretive	Informational (In)
2.12	Probing	Informational (In)

IBMS Learner Categories		Influence Effect (IE_L)
1.	On-task	Movement toward (+)
2.	Off-task	---
2.1	Self-involvement	Movement away (o)
2.2	Noise	Movement away (o)
2.3	Verbal Interaction	Movement away (o)
2.4	Physical Interaction	Movement away (o)
2.5	Verbal Aggression	Movement against (-)
2.6	Physical Aggression	Movement against (-)
2.7	Verbal Resistance	Movement against (-)
2.8	Physical Resistance	Movement against (-)

Teacher legitimate power. The teacher attempts to influence the learner on the basis of the teacher's role or socially defined authority ("Because I am the teacher I have a right to tell you what to do."). Three IBMS categories are of this type: demand, condition-stimulus, and value-law. Teacher 'demand' is a verbal command to the learner to cease his/her off-task behavior and/or return to the task. Teacher 'conditioned-stimulus' is a signal or cue which has the implicit meaning of a demand ("shh," "Hey!", clears throat, stares menacingly). Teacher 'value-law' is an appeal to an established classroom norm of action ("You know that you must ask for permission to talk to your friend.").

Teacher expert power. The teacher attempts to influence the learner on the basis of authoritativeness (not authoritarian influence) on the basis of the teacher's superiority of knowledge or skill. Two IBMS categories seem to fit this type of influence: teacher task and redirection. Teacher 'task' means that the teacher continues to engage in the tasks of instruction. If the learner is misbehaving, the teacher makes no references to the learner's misbehavior; and teacher task in this situation could be construed as intentional ignoring, if the teacher were aware of the deviance. Teacher 'redirection' is moving the learner to an appropriate task without reference to the misbehavior (Johnny has been teasing Sally and the teacher says, "Johnny, come up here and help me pass out these papers.").

Teacher referent power. The teacher attempts to influence the learner on the basis of the learner's identification with the teacher (the learner acts appropriately because s/he likes the teacher as a friend, or because s/he respects the teacher as a person). Two IBMS categories seem to be of this type: empathic-sympathetic and humor.

Teacher informational power. The teacher attempts to influence the learner on the basis of validity or truth of knowledge ("You should not smoke in class because it is dangerous to your health as well as ours. Medical research has shown a correlation between smoking and lung cancer and other respiratory diseases."). Two IBMS categories seem to characterize this type of influence: teacher interpretive and probing. The former is a giving of reasons for learner misbehavior ("You're sulking because no one chose you on their team."); whereas the latter is an asking for reasons for learner misbehavior ("Why did you hit Sam?").

While French and Raven (1959) intended these categories of influence[6] to characterize the influence relations of the influencee and the agent of influence, it seems reasonable to use them to characterize the attempts of the agent of influence. Of course, the purpose of influence is to bring about a change in the influencee according to the agent's objectives. Not always will the attempt succeed, and therefore it is informative to characterize the effects of the influence attempt. They can be characterized by moving toward, away, and against.

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[6]The sixth category, information, was considered as a type of influence in that work (1959), but was not formally included until later.

Learner effect of moving toward. The effect on the learner is that the learner acts (or believes) in accordance with the agent's (teacher's) objectives. The IBMS category, learner on-task, is just this effect.

Learner effect of moving away. The effect on the learner is that the learner does not change in the desired direction as a consequence of the influence attempt, but the learner does not oppose or resist the influence attempt. Previous or current learner acts or beliefs persist, which are not in accordance with the teacher's objectives. Four IBMS learner off-task categories seem to fit this type of effect: learner self-involvement, noise, verbal interaction and physical interaction. These are learner behaviors which are neither on-task nor overtly aggressive/resistive of teacher controls.

Learner effect of moving against. The effect of the teacher influence attempt on the learner is one of the learner's definite opposition to the teacher. Four IBMS learner off-task categories seem to fit this type: learner verbal aggression, physical aggression, verbal resistance, and physical resistance.

Now that influence attempts and influence effects have been described, one might hypothesize the kinds of effects that would result from each type of influence. Raven has viewed the effects in a fourfold manner. For each type of influence, the effect on the influencee can be characterized by the nature of the social interaction with the agent of influence, the nature of identification with the agent, the opinion of or belief in the task expected by the agent, and the actual task engagement or task behavior. For example, the teacher might scold the learner (coercive influence attempt) which might result in appropriate task behavior (+behavior effect), but also might result in feelings of hostility towards the teacher (- identification), social interaction which was unfriendly (- social interaction), and dislike of or disbelief in the task expected (- opinion/belief).

In the IBMS only one of the fourfold effects posited by Raven can be characterized--task behavior (+, Ø, -). In Project PRIME many other measures of the learner were collected, which would characterize some of the other effects suggested by Raven. For purposes of illustration here, we will only be concerned with the IBMS in exemplifying some of SIGGS information properties.

SIGGS Framing of Influence Relations

Mainstreaming of mildly handicapped learners into regular classroom settings came about as a result of growing concern over the long-range deleterious effects of educational labeling and segregation of handicapped children in self-contained special classes. Mainstreaming was also given further impetus by court litigation emphasizing unjust discrimination against minorities and lower socioeconomic classes in labeling and placement in special classes (Kaufman, et al., 1973).

Special education came about early in this century in order to give special instruction to those students who were not able to successfully adapt to the modes of instruction in the regular classroom. A dilemma

is evident. If the child who previously could not function acceptably in a regular class was placed in a special class and is now brought back to the regular class, why should we expect him/her now to function acceptably? The issue is complex. This is why the question is addressed in Project PRIME: for whom and under what conditions is mainstreaming of mildly handicapped children a viable educational alternative? Is mainstreaming viable only in non-academic subjects? Only for females? Only for MR's regular classrooms which are of similar ethnic and SES composition? Only in regular classes in which the teacher favors mainstreaming? Only in classes where the regular classmates socially accept the handicapped child? Only in third-grade, but not fourth and fifth-grade?

The word 'viable' is significant here, because we must ask: viable for whom--the handicapped child, the regular classroom teacher, regular classroom peers, or the school principal? We must ask further: What are the indicators of viability? For the handicapped learner who is mainstreamed, some of the indicators might be:

- feels secure, comfortable, accepted in the regular class,
- desires to learn in the regular class,
- is able to learn in the regular class,
- is able to get along socially with the regular classroom teacher and peers.

For the regular classroom teacher who is to instruct the mainstreamed learner, some of the indicators might be:

- is comfortable with and accepts the handicapped learner,
- desires to teach the handicapped learner,
- interacts with and gives handicapped child individual attention like any other student,
- plans classroom activities which include the handicapped learner.

In this next illustration, we will initially focus on the influence attempts of the teacher, and the influence effects on the learner. If the learner is moving toward (+) the task expected by the teacher, this would indicate that the learner is probably attempting to learn, which would be a desirable outcome of mainstreaming. If the learner is moving away (Ø) or moving against (-) the learning task expected by the teacher, this would indicate that the learner is probably not attempting to learn or is overtly opposing the learning task or teacher.

Let us take the regular classroom as the universe of discourse, and the mainstreamed handicapped learner as the system of focus in SIGGS. (See Figure 8). The learner's negasystem would include the teacher, peers, books, and chairs. When the teacher attempts to influence the learner, the teacher is learner toputness in SIGGS. That is, the teacher becomes information which is available to the learner system. When subsequently taken in by the learner system, toputness is said to effect inputness. Learner inputness is then the effect of the teacher influence on the learner system. This relation is feedinness, or the sharing of information between toputness and inputness, when toputness occurs just prior to inputness. We can characterize the uncertainty of this feedinness relation by information statistics.

Information Statistics

In Table 6 the joint classification of learner toputness (T) and inputness (I) is illustrated. Note that the requirements of information theory have been satisfied here. Each and every occurrence of a teacher influence can be characterized by one and only one category (component) of the classification of influence attempts ($1A_T$). Likewise, these information requirements are satisfied by the components of the classification on the learner system (IE_L). If these requirements were not met we could not legitimately use information (uncertainty) statistics to describe the joint classification. Feedinness characterizes the flow from toputness (information in the negasystem which is available to the system) to inputness (which is a system with selective information). That is, how are changes in teacher influence attempts related to changes in learner task behavior? We can characterize the uncertainty of this affect relation by a T statistic. T is comprised of H statistics. The H statistic is the basic information or uncertainty statistic.

H is used to describe the average uncertainty of occurrences of categories in a classification.[7] H is a nonmetric statistic, because there is no metric in a nominal classification. Analogously, variance (0^2) is a metric statistic used to indicate average dispersion of interval measures around the center of the distribution, which is the mean, M.

When H is zero, there is zero uncertainty, or total certainty. When H is greater than zero, there is some uncertainty. H can never be less than zero. The formula for H is given:

$$(1) \quad \underline{H}\,(\underline{C}) = -\sum_{i=1}^{n} p\,(\underline{c}_i) \times \log_2 p\,(\underline{c}_i)$$

This formula is read: the average uncertainty, H, of an occurrence of any category in the classification, C, is equal to the negative sum of the N respective products of the probability of each category, P (c_i), and the logarithm to the base two of its probability, $\log_2 p\,(c_i)$. This results in a positive value of H because the logarithm of a fraction is negative.

Suppose we characterize the uncertainty of 1884 occurrences of learner behavior. For example, if the learner was 'moving toward' we would make a tally in the '+' cell of the below table.

	+	∅	−	
frequencies	911	811	162	Total = 1884

[7] See Coombs, et al. (1970) and Atteneave (1959) for a more detailed discussion of information statistics.

Table 6. Characterization of the Feedinness Relation Between Learner Toputness Which Is Teacher Influence Attempt and Learner Inputness Which Is Influence Effect.

Antecedent Learner Toputness ($T=1A_T$)	Consequent Learner Inputness ($I=IE_L$) +	∅	−	
Reward (Re)	94	283	59	436
Coercive (Co)	05	22	0	27
Legitimate (Lg)	132	69	12	213
Expert (Ex)	479	437	18	934
Referent (Rf)	82	0	0	82
Informational (In)	119	0	73	192
	911	811	162	1884

$$\underline{H}(I) = -\left[\left(\frac{911}{1884} \times \log_2 \frac{911}{1884}\right) + \left(\frac{811}{1884} \times \log_2 \frac{811}{1884}\right) + \left(\frac{162}{1184} \times \log_2 \frac{162}{1884}\right)\right] = 1.335$$

$\underline{H}(T) = 1.967$ $\underline{H}(TI) = 3.056$

Feedinness = $\underline{T}(T,I) = 1.335 + 1.967 - 3.056 = .246$

$\underline{rT} = [T(T,I)/H(I)] \times 100$

= (.246/1.335) X 100 = 18% reduction uncertainty

When we finished counting up the tallies we observe that the learner was moving toward (+) 911 times, moving away ø 811 times, and moving against (-) 162 times. Given these data, at any given time the learner is most likely to be moving toward, slightly less likely to be moving away, and not very likely to be moving against. We can mathematically characterize this uncertainty by calculating an H for this distribution of learner inputness (I):

$$H(I) = -\left[\left(\frac{911}{1884} \times \log_2 \frac{911}{1884}\right) + \left(\frac{811}{1884} \times \log_2 \frac{811}{1884}\right) + \left(\frac{162}{1884} \times \log_2 \frac{162}{1884}\right)\right]$$

$$= 1.335$$

What does this H = 1.335 mean? There is obviously some uncertainty. If there were no uncertainty, H = 0. But it is helpful to know what the maximum uncertainty would be if each of the three categories were equally (i.e., same frequency in each cell). Maximum uncertainty, Hmax, is defined:

(2) $Hmax = \log_2 n$

where, n = number of categories in the classification.

For two categories, Hmax = 1; for eight , Hmax = 3; for four, Hmax = 2. For the three categories we have, Hmax = 1.585. Our H (I) = 1.335, which is closer to Hmax than it is to zero. More specifically, we can calculate relative uncertainty, rH, by the below formula:

(3) $$rH(C) = \left[\frac{Hmax - H(C)}{Hmax}\right] \times 100$$

or $$rH(C) = \left[\left(1 - \frac{H(C)}{Hmax}\right)\right] \times 100$$

Therefore, in our example,

$$rH(1) = \left[1 - \left(\frac{1.335}{1.585}\right)\right] \times 100 = 15.8\% \text{ reduction of uncertainty}$$

We can say that knowledge of the given distribution of 1884 occurrences of learner behavior reduces (from maximum) the uncertainty with which we could predict which inputness category is occurring(or might occur next) by approximately 16 percent.

We can calculate H for joint or multiple classifications. In general,

(4) $$H\left(C_{IJK\ldots}\right) = \sum_i \sum_j \sum_k \cdots p\left(c_{ijk\ldots}\right) \times \log_2 p\left(c_{ijk\ldots}\right)$$

Table 7. Characterization of $L_i \rightarrow L_f$ Affect Relations

Consequent
Learner Fromputness
($F=1A_L$)

Antecedent Learner Inputness ($I=IE_L$)	+	∅	−	
+	X	855	56	911
∅	733	X	78	811
−	100	62	X	162
	833	917	134	1884

$\underline{H}(I) = 1.335$
$\underline{H}(F) = 1.297$
$\underline{H}(IF) = 1.775$

System Flow = $\underline{T}(I,F) = 1.335 + 1.297 - 1.775 = .857$

$\underline{rT}(I,F) = (.857/1.335) \times 100 =$ 64% reduction of uncertainty

Table 8. Characterization of the Feedoutness Relation Between Learner Fromputness Which is Learner Influence Attempt and Learner Outputness Which Is Teacher Influence Effect

Consequent Learner Outputness ($O=IE_T$)

Antecedent Learner Fromputness ($F=1A_L$)	Re	Co	Lg	Ex	Rf	In	
+	81	0	0	752	0	0	833
∅	12	0	127	571	125	82	917
-	2	47	85	0	0	0	134
	95	47	212	1335	125	82	1884

$\underline{H}(F) = 1.297$

$\underline{H}(O) = 1.519$

$\underline{H}(FO) = 2.356$

Feedoutness = $T(F,O) = 1.297 + 1.519 - 2.356 = .46$

$rT(F.O) = (.46/1.519) \times 100 = 30\%$ reduction of uncertainty

In Table 6 the uncertainty of the joint classification of toputness and inputness is calculated: $\underline{H}$ (TI) = 3.056.

Now we have all the formulas we need to calculate the $\underline{T}$ statistic for the relation between two or more classifications: the formula for $\underline{T}$ for two classifications is defined:

$$(5)\ \underline{T}(\underline{C}_I, C_J) = (\underline{H}\ (\underline{C}_I) + \underline{H}(\underline{C}_J) - \underline{H}\ (\underline{C}_{IJ}).$$

In Table 6 it can be seen that $\underline{T}$ (T,I), or feedinness, is .246. $\underline{T}$ is somewhat like a correlation coefficient, except that $\underline{T}$ can vary from zero upwards. When $\underline{T}$ is zero there is no relation; when $\underline{T}$ is greater than zero there is some relation, or some sharing of information between two classifications (here, between toputness, T, and inputness, I).

We can also calculate a relative $\underline{T}$, just as we estimated a relative $\underline{H}$. Relative transmission is defined:

$$(6)\ \underline{rT}\left(\underline{C}_1\ ,\ \underline{C}_J\right) = \left[\underline{T}\left(\underline{C}_1\ ,\ \underline{C}_J\right) / \left(\underline{H}\ \left(\underline{C}_J\right)\right)\right] \times 100.$$

Relative transmission is akin to the r^2 interpretation in metric statistics. We say that if $\underline{r}$ = .8, the r^2 = .64, or 64% of the variance in one interval level variable is explainable by the other interval variable. Relative transmission, $\underline{rT}$, which is non-metric, is akin to eta-squared (correlation ratio, squared) in standard analysis of variance interpretation. (Costner, 1965; and Schmitt, 1969.) See Table 7.

In our fictitious example in Table 6, relative transmission is (.246/1.335) X 100, or an 18 percent reduction of uncertainty in learner outputness given knowledge of toputness. We could conclude here that there is little commonality between antecedent teacher influence attempts and consequent learner influence effects. That is, regardless of which type of influence the teacher chooses, there is little change in the relative pattern of learner behavior.

Fruitfulness of SIGGS

The reader might feel at this point that, other than application of information statistics, there is not much difference between a SIGGS framing of teacher learner influence and a more traditional framing (see Figure 1, Schemas 1.1. and 1.2.). The point of the simple example in Table 6 was to illustrate the basic information statistics, $\underline{H}$ and $\underline{T}$. There are many other properties of SIGGS besides feedinness, however. A few of these other properties will be touched upon here to illustrate how SIGGS can extend extant models.

In Table 8 the influence of the learner on the teacher is mapped. Feedoutness is flow from fromputness to outputness. Here antecedent learner behavior is viewed as an influence attempt by the learner (IA_L) and the consequent teacher behavior is viewed as the effect of the learner influence on the teacher (IE_T). Feedoutness, or transmission from the learner to the teacher, is .461. Compare this with feedinness of .246. The learner influences the teacher more than the teacher in-

fluences the learner in this fictitious example. Relative feedoutness yields a 30 percent reduction of uncertainty. That is, knowledge of anticedent learner influence attempt (here characterized by +, Ø, -) reduces the uncertainty of consequent teacher effect by about 1½ times as much as the converse (30% vs. 18%).

Feedthroughness can show us the flow in time from the teacher (toputness) through the learner (inputness, fromputness) and to the teacher (outputness). Feedthroughness is defined mathematically as a multivariate T of order four:

$$(7)\quad \underline{T}(T, I, F, O) = \underline{H}(T) + \underline{H}(I) + \underline{H}(F) + \underline{H}(O) - \underline{H}(TI) - \underline{H}(TF) - \underline{H}(TO) - \underline{H}(IF) - \underline{H}(IO) - \underline{H}(FO) + \underline{H}(TIF) + \underline{H}(TIO) + \underline{H}(TFO) + \underline{H}(IFO) - \underline{H}(TIFO).$$

It can be seen that we need for feedthroughness the joint classification of toputness (T), inputness (I), fromputness (F), and outputness(O), where T is t_1, I at t_2, F at t_3, and O at t_4; and t_1, t_2, t_3, t_4, are successive moments in time. Joint classification with more than two classifications is difficult to illustrate in a table, but the reader can get a feeling of this flow by looking successively at Tables 6, 7 and 8.

Probably more interesting than feedthroughness (teacher⟶learner⟶teacher) is compatibleness (see Table #2). Compatibleness is commonality of feedinness and feedoutness, and can be estimated by the $\underline{B}$ function, which is comprised of $\underline{T}$'s. (Maccia and Maccia, 1966, pp. 20-23; the formula for B compatibleness' consists of 9 $\underline{T}$'s, which in turn consist of 27 $\underline{H}$'s.) Intuitively, compatibleness characterizes the relation between what is taken in by a system from its environment, and what is subsequently taken in by the negasystem from the system. If there is little compatibleness between a teacher and mainstreamed learner, one might expect strainness in the learner and/or stressness in the teacher to increase (see Table 2, #65 and #66). If strainness in the learner increases beyond a certain level we might then expect his/her anxiety level to increase, which might in turn lead to hostile or aggressive interaction with the teacher and/or peers. This antagonism might foster social rejection by peers and teacher negative feelings toward the mainstreamed handicapped learner. This could lead to exclusion of the handicapped child from regular classroom activities. The handicapped child would be, in effect, isolated from the regular classroom, although physically present. That is, there would be disconnectionness in the classroom system (see Table 2, #35). Such a situation would not be a viable outcome of mainstreaming.

Conclusions

Only a few of the SIGGS properties were considered in discussing the potential fruitfulness of SIGGS in extending research questions in

Project PRIME. Adaptiveness (#29 in Table 2) was not considered, for example. "Adaptiveness is a difference in compatibleness under system environmental changeness" (Maccia & Maccia, 1966, p. 53). Adaptiveness of the mainstreamed handicapped learner to the regular classroom might very well be one of the most important considerations in mainstreaming.

Also, it should be noted that components in the learner system and teacher system were rather crude and simplistic. Learners consist of more than just task behavior of moving toward, away, and against. Learners have feelings, intentions, and knowledge as well. These could be characterized by storeputness in SIGGS, for example.

Moreover, the categories of teacher influence were not the same as those for the learner. These teacher/learner categories were probably devised originally in a mechanistic framework (i.e., only in terms of the teacher influencing the learner, but not the converse). In an organismic framework it is obvious that the learner can influence the teacher as well. That is, in SIGGS, there is a feedoutness in addition to feedinness. Therefore, we should be using the same categories for the learner as for the teacher, because the influence is mutual. It was not feasible to have the same categories for each, obviously in the example with Project PRIME, because it was originally conceptualized as an Input ⟶ Process ⟶ Output study.

In addition, the learner negasystem consists of more than just the teacher. There are curriculum and setting components, which can influence, as well as be influenced by, the learner system. These can easily be handled in SIGGS by the multivariate information statistics.

As was stated earlier, this paper is considered only as a beginning. It should be clear to the reader at this point, however, that the extended general systems model (SIGGS) can be a powerful and fruitful heuristic for researching education. It is hoped that further application of this model will contribute significantly to a science of education.

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AN APPROACH TO INSTRUCTIONAL DESIGN USING SUCCESSIVE MODELS

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Introduction

The purpose of this paper is to describe a method for planning educational program development. This method draws all elements of the planning, design, execution, and evaluation of a program into one systematic unit. Through the use of this method the development of an educational program can be done in systematic stages.

This is not a new approach to program planning and instructional design, but with the addition of certain elements into the traditional process, several benefits can be realized. All instructional programs have three areas of concern. The first is the content to be taught. The second is the process for learning or the teaching strategies that are used to teach the content. And, the third is the logistical elements of teaching. This includes such considerations as class size, meeting schedule, and classroom arrangement. The approach discussed here suggests that three models be developed from the program goals as the first stage in instructional design. These three models describe the three areas of concern discussed above. From these models the specific objectives for learning, process, and logistics are developed. From the objectives the program is planned. Finally, from the objectives the evaluation strategies are developed.

By using the models, all elements of the program are visualized, which makes planning easier. Also, by developing objectives from the models for all three areas it is easier to plan comprehensive program activities, and the evaluation design can be developed to cover all aspects of the program.

This paper is divided into two parts. The first part explains the approach to instructional design. The second part illustrates how this approach was used to develop a large scale program in Allied Health Professions education. This program is called Kentucky January. It is a very complex program and its development provides an excellent example of how instructional design using successive models can be accomplished.

Philosophy of Successive Models

Program development and evaluation are highly related parts of the same process. Successful programs depend on careful development, and development depends on the feedback provided through evaluation. However, both development and evaluation depend on planning. Program planning is the key to program development and, as such, it must be undertaken in a systematic fashion.

Generally, program planning is a two step process: 1) the general program goals are defined, then 2) learning objectives are defined that categorize the goals into specific desired outcomes or behavior. Here we present an extension of the planning process that will help in program development, especially when the program is a complex one. This approach calls for the development of process models that define and give direction to the dynamic learning situation the program will generate. These models are a bridge between the program objectives and the actual design of the instructional sequence.

This approach uses successive models of What, How, and Where people learn to provide strategies for the design of instructional sequences. The first step is a model of the structural organization of the behavioral outcomes. This is a hierarchal illustration of how the behaviorial outcomes fit into an organized system of knowledge and skills. The second step is a model of the specific human mechanisms for learning, motivation, and attention that are utilized in the acquisition of the desired instructional outcomes. The third step is a model of the environmental structure necessary to facilitate the desired learning. This model for instructional design and development is presented in Figure 1. In this figure we can see how the planning stage leads to the design stage, and finally how evaluation provides feedback into the development process.

This approach provides for a complete modeling of the whole program development process. The three process models provide a framework whereby all the components of a program can be developed. In Figure 2 this framework is presented.

The model of what people learn leads to the learning objectives which lead to the teaching strategies. These in turn lead to the evaluation strategies for what is learned.

The model of how people learn leads to process objectives that affect the development of the teaching strategies. The most effective teaching strategy is one that makes the best use of the human dynamics that are generated by the program. For example, in a small group situation an interactive strategy--a game or a project--is more effective than individual reading assignments. The model of how people learn helps the instructional developer to capitalize on the dynamic elements inherent in the program and thus to increase the probability of effective learning. Finally this leads to evaluation strategies that determine the effectiveness of the learning environment provided by the program activities.

The model of where people learn is the final element in the total program model. From this model comes the logistics of the program. Finally, evaluation strategies to gather feedback on the program operation are developed.

Evaluation takes on two distinct forms: formative and summative. Strictly speaking the formative form is used to improve the actual teaching sequence. Here the effects of the teaching program are compared to the learning

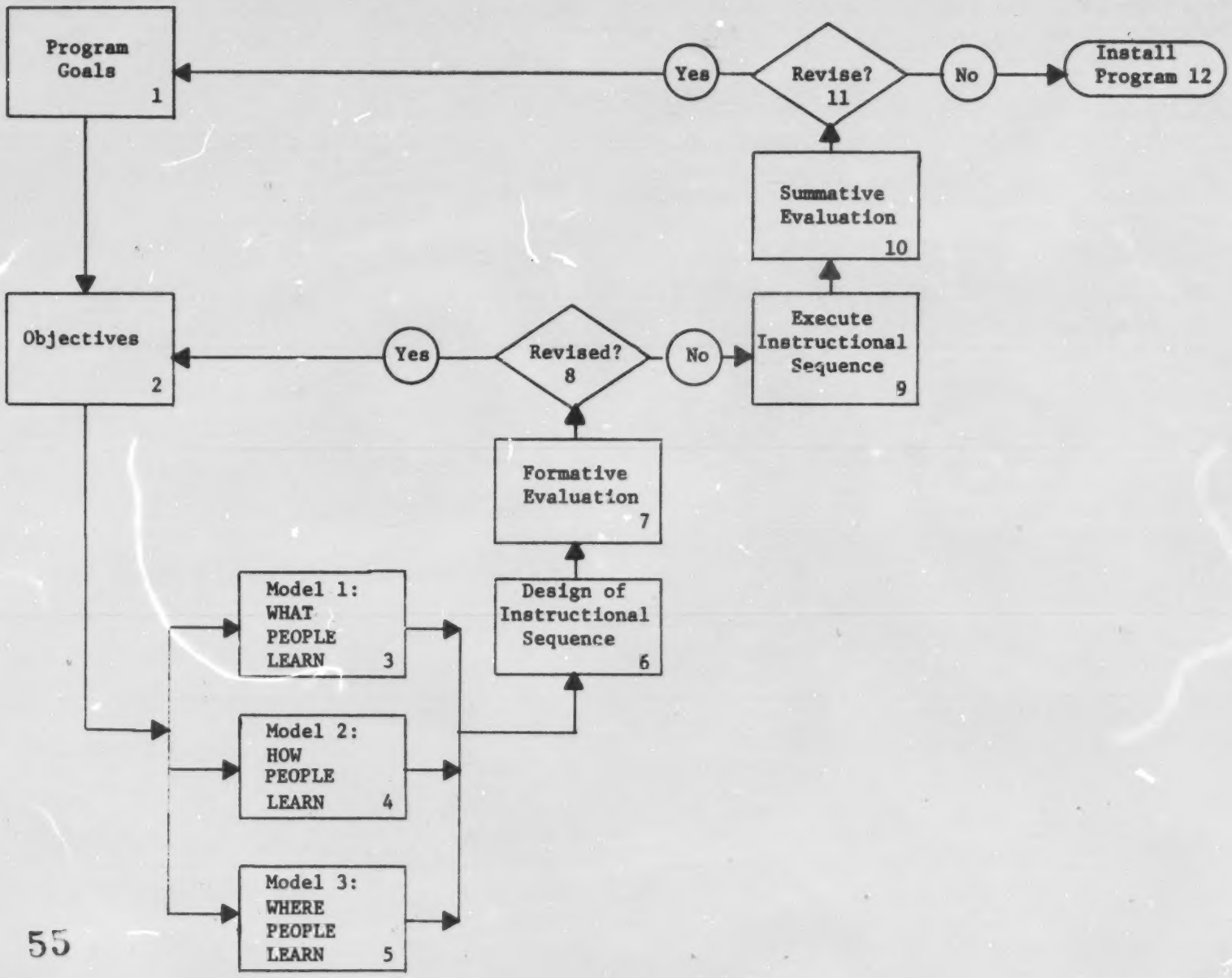

FIGURE 1
MODEL OF INSTRUCTIONAL DESIGN AND DEVELOPMENT USING SUCCESSIVE PROCESS MODELS OF WHAT, HOW, AND WHERE PEOPLE LEARN

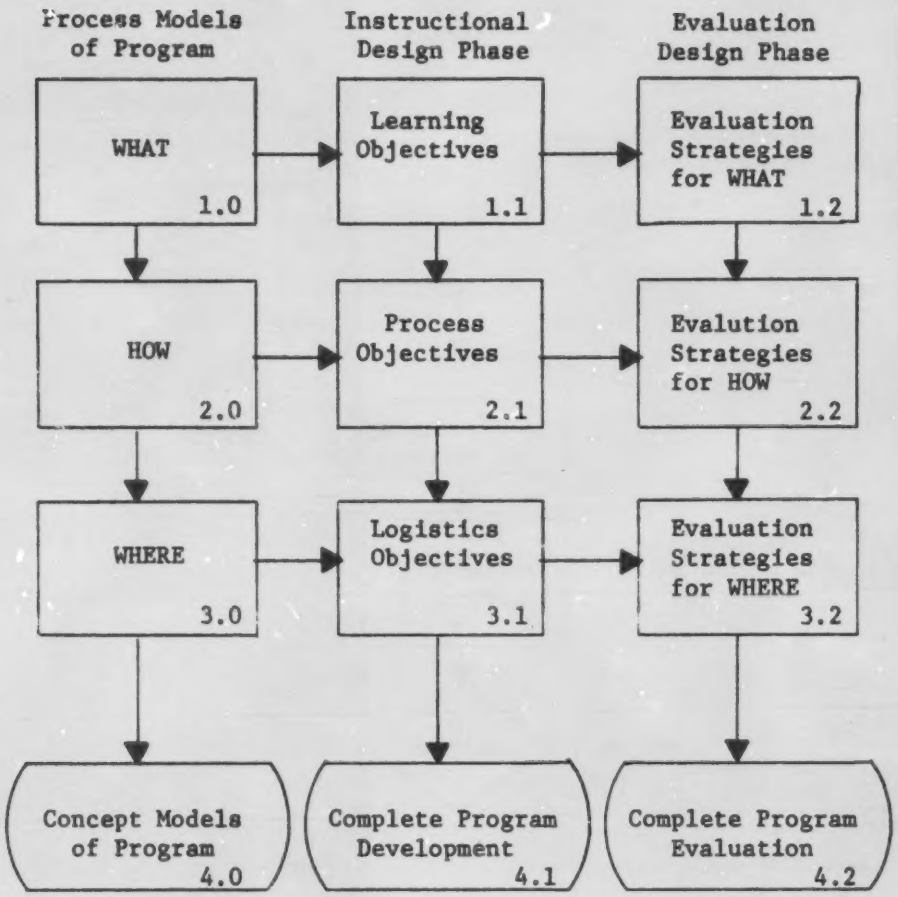

FIGURE 2

FLOW DIAGRAM FOR USING PROCESS MODELS FOR INSTRUCTIONAL DESIGN AND EVALUATION DEVELOPMENT

objectives, and deficiencies in the teaching sequence lead to revision of the objectives, models and/or instructional strategies. The summative form is used to decide if the program goals are being reached. If deficiencies are found here, revision of the entire process from goals to teaching sequence is considered.

In theory, formative evaluation is used first on portions of the program and summative evaluation is applied last to the whole program. In practice both forms of evaluation are used at the same time.

Planning Models for Kentucky January

The Kentucky January Project has sent allied Health students into the field during the month of January since 1973. From 1973 to 1975 almost 400 students participated in the program. In 1976 about 180 students from the Allied Health professions, Nursing, Education, and Social Work participated.

The overall purpose of Kentucky January is to teach students about the Health Care Delivery system and to show them the benefits of a teamwork approach to health care. This purpose has been accomplished by a combination of on-campus and in-field learning experiences. The on-campus phase occurs during the Fall semester and is mainly an orientation and preparation period. The major phase of the program occurs in the field. The "field" is 25 sites scattered throughout the state of Kentucky. Student groups of 7 to 9 people plus a faculty sponsor are sent to each site to spend the month of January studying the health care system. Some sites are rural and some are urban. All sites have a hospital, physician and dental offices, health department, nursing home, and a home health agency. The "base" for the team is the hospital, and a hospital staff member is appointed as Location Coordinator to help the team in their tasks.

There are two types of teams: observational and clinical. An observational team observes and studies the health care environment and the application of teamwork to health care. A clinical team also studies the health care environment, but this team experience comes from actually delivering health care as a team and by working within the system rather than by observing it.

The program development undertaken for the Kentucky January project did not follow the ideal that was presented in the section above. Since the Kentucky January project had been executed three times prior to the beginning of the formal development process in September 1975, program goals and teaching sequence were already in existence. Thus, we worked backwards from the existing teaching program to the program goals, and then went forward to develop learning objectives, the process models, and a revised teaching program.

The program goals for Kentucy January are presented below:

1. Provide the students an experience that will allow them to define the team concept, apply the concept, and identify the potential of teamwork in the practicing environment.

2. To understand the concept of the Health Care Environment, its sub-environments, and its relation to the World Health Organization's definition of Health. Recognize potential areas for improvement and areas to effect improvement in the Health Care System and the Health Care Environment.

From these two program goals, sub-goals and learning objectives were developed. The objectives were developed by the Kentucky January staff and reviewed by members of the faculty of the College of Allied Health Professions, College of Social Professions, and College of Nursing.

The three process models of What, How, and Where were designed to assist the program developers in visualizing the program. The complex learning process, the group/team organization used for the students, and the combination of classroom, small group and in-field elements of the learning environment make for a program that is hard to visualize and difficult to plan. The models reduce some of this complexity.

The learning process model, What is learned, is presented in Figure 3. This model illustrates the sequence in which the sub-goals and learning objectives are learned.

The model of internal human organization, How people learn, is presented in Figure 4. This model illustrates the small group nature of the Kentucky January program. The students and their faculty sponsor form an interdependent group that is placed in an unfamiliar environment. The students and faculty sponsor depend on each other for direction and support. Thus this group becomes a powerful force on each individual and each individual will in turn work for the goals set by the group. All of the teaching strategies are designed to enhance and utilize this interdependence to achieve the program goals.

The model of the environmental organization, where people learn, is presented in Figure 5. This model indicates, against a time line, the various activities and meetings that make up the program. The type of meeting influences the instructional strategies used. Also, some of the activities are strategies in themselves. The bulk of the program is executed through the field site visits and field meetings, so the teaching program is aimed primarily toward these areas. However, the earlier meetings and activities are important as they supply preliminary information needed for the field experience.

Some goals are relative to the faculty sponsor. It should be noted that there are faculty meetings listed in Figure 5. Faculty, as well as students, are expected to learn about teamwork and the health care system. Old as well as new faculty profit from the opportunity to get out of the university setting and into the field.

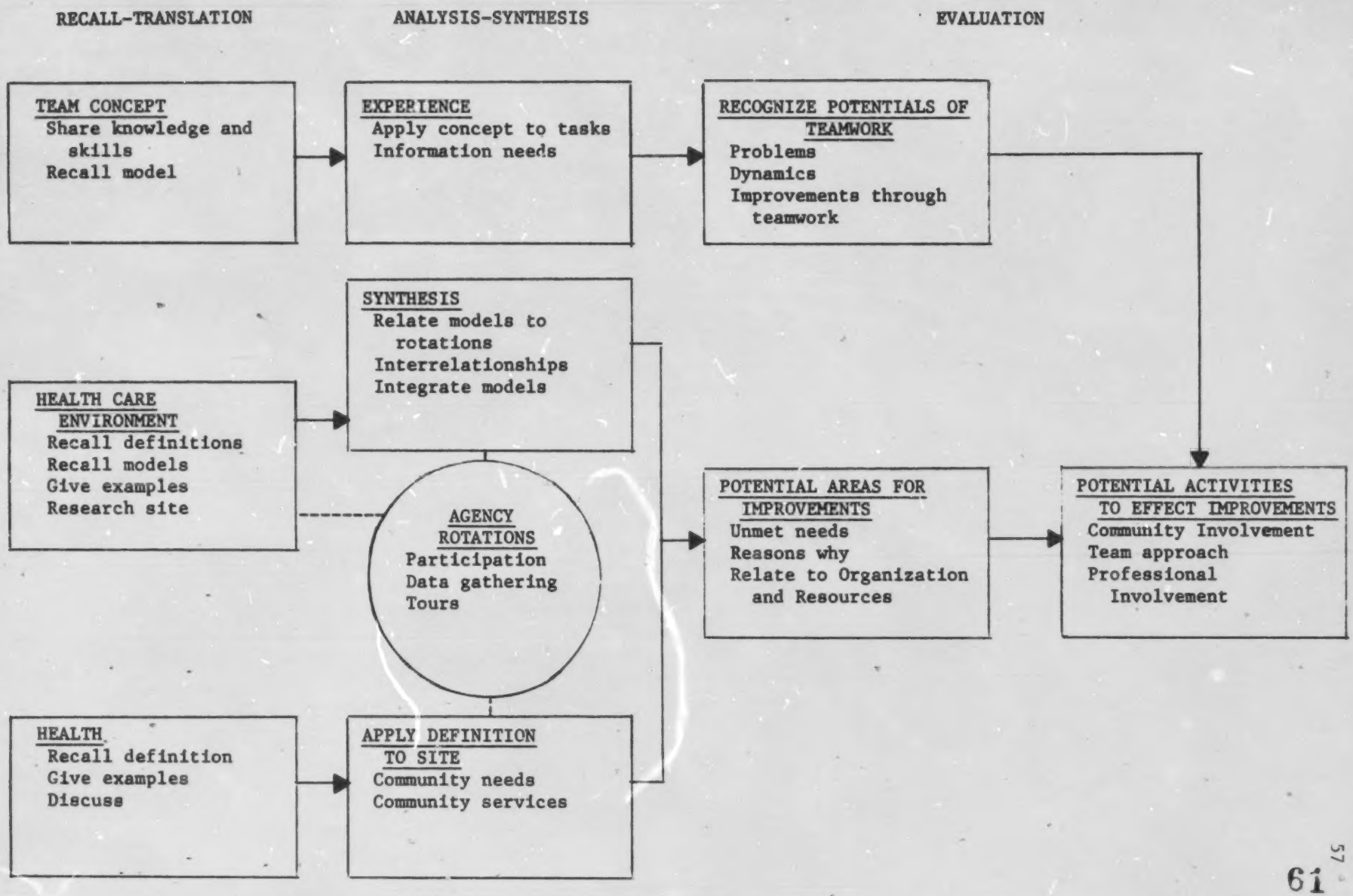

FIGURE 3
MODEL OF SYSTEM OF KNOWLEDGE/LEARNING PROCESS (WHAT) FOR KENTUCKY JANUARY PROGRAM

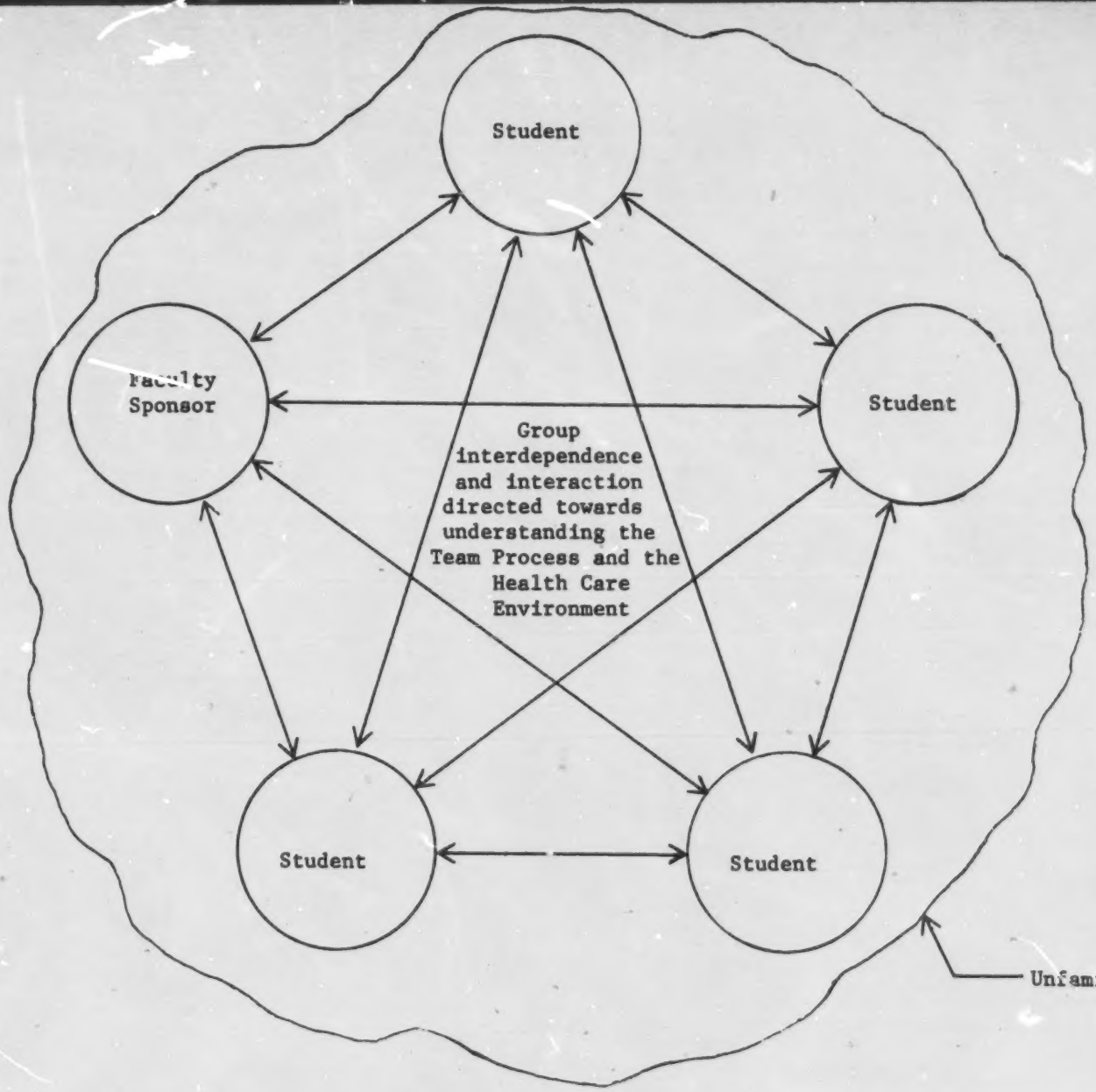

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Figure 4
MODEL OF INTERNAL HUMAN ORGANIZATION (HOW) FOR KENTUCKY JANUARY PROGRAM

The teaching programs made up of the Translator Document and the Teaching Aids, were developed from the objectives and these models. Copies of the teaching materials are contained in the Faculty Sponsor Manual.

Evaluation Design and Goals

From the models presented above, evaluation goals were developed. From the learning process model came a series of evaluation goals that paralleled the goals and sub-goals of the program itself. In general these evaluation goals ask "did the students learn what was expected?" From the model of how people learn came several goals that generally ask "did the group development process occur and did it lead to effective learning?" Finally, from the model of where people learn came evaluation goals aimed towards attendance at meetings, suitability of meetings, logistics of the site visits, and suitability of accommodations, meals, and transportation.

Learning Process Strategies

The evaluation goals developed from the learning process model of the Kentucky January program parallel the learning goals. The relationship between the learning goals and specific evaluation strategies are summarized in Table 1. The strategies basically fall into two categories: 1) objective measurement instruments and 2) a subjective report.

The objective measurement instruments are 1) Recall Test, 2) Health Care Environment Test, and 3) Health Professions Attitude Survey. These three instuments are administered on a pre-post-test basis and are used to measure change in knowledge at the Recall and Analysis levels, and attitudes made during the program.

The subjective Team Final Report is written to a specific outline and is designed to appraise the Analysis, Synthesis, and Evaluation portions of the learning process model (see Figure 3). The reports are content analyzed, using the outline, program goals and sub-goals as guides, by the program developers and the Allied Health faculty. A checklist of what to look for and a reconciliation process will be used to achieve consensus among the people analyzing the reports.

Group Development Strategies

The evaluation goals drawn from the How People Learn model (Figure 4) are presented in Table 2. The strategies for these goals are two attitude scales, Group Effectiveness Scale and Climate Gauge, and the Team Final Report. The Group Effectiveness Scale is administered five times and provides a measure of group development. The Climate Gauge is administered daily during the field program to a random sample of students. It provides

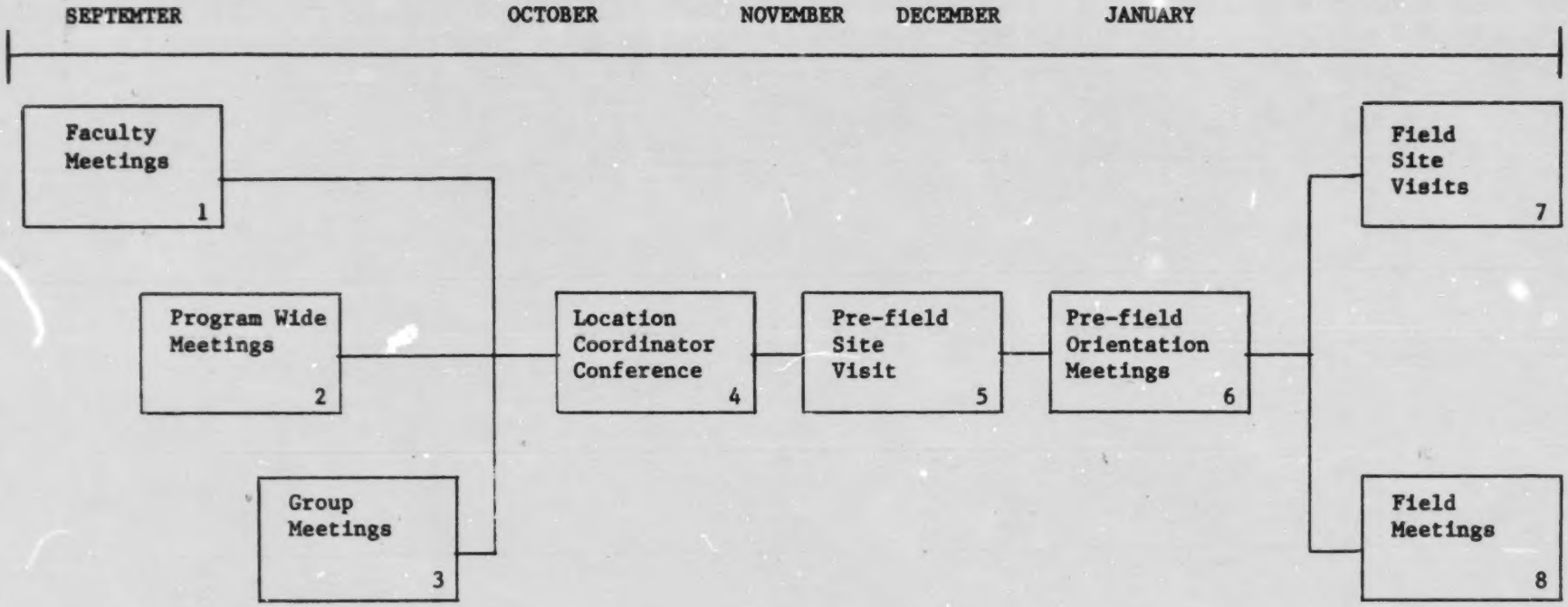

FIGURE 5
MODEL OF EXTERNAL ENVIRONMENTAL ORGANIZATION (WHERE) FOR KENTUCKY JANUARY PROGRAM

TABLE 1

EVALUATION GOALS AND STRATEGIES FOR LEARNING OUTCOMES

Learning Subgoals/Evaluation Goals	Evaluation Strategy
Team	
1. Have a basic recall understanding of Kentucky January Team Concept.	Recall Test
2. Share professional knowledge and skills; breakdown stereotypes.	Health Professions attitude Survey, Team Final Report (parts I.A. & I.B.)
3. Apply Team concept to tasks	Team Final Report (part I.C.)
4. Gain a basic knowledge of group dynamics.	*
5. Recognize problems/issues involved in teamwork and possible solutions to problems.	Team Final Report (part I.C.)
6. Recognize potentials of teamwork and how teamwork/Kentucky January Team concept can be applied to improve the Health Care Environment.	Team Final Report (parts I.D. & III.B.)
Health Care Environment	
1. Have a basic recall knowledge of the Health Care Environment.	Recall Test
2. Have a recall understanding of the WHO definition of Health.	Recall Test
3. Information gathering	*
4. Synthesis of Rotational Experience.	Health Care Environment Test Team Final Report (parts II.A. & II.B.)
5. Apply definition of Health & Site.	Team Final Report (Part II.C.)
6. Recognize potential areas (unmet needs) for improvement.	Team Final Report (Part II.C.)
7. Recognize potential areas to effect improvements in the Health Care Environment.	Team Final Report (parts III.A., III.C. & III.D.)

NOTE: Goals are not directly evaluated, but successful completion of other goals would imply that these goals, which were prerequisites, were accomplished.

a measure of student attitude towards the program, their group, their faculty sponsor, and themselves. The section of the Team Final Report that deals with group development will provide information regarding the issues and problems faced by teams and their success in coping with the problems.

Meetings, Logistics, and Usage of Teaching Tools

From the model of the external environment, where people learn, come several evaluation goals related to meetings and program logistics. These goals and the strategies developed to measure them are presented in Table 3. Also, included here are goals for the evaluation of the efficiency and utilization of the Teaching Aids and the evaluation of the degree to which the suggested learning sequence was followed.

This information is gathered primarily through two forms: 1) The Fall Activities Form which is administered prior to going into the field, and 2) The Open Ended form which is administered, in slightly different versions, after the field experience to students, faculty sponsors, and location coordinators. The pre-administration of the Recall Test is done just prior to going into the field. Thus, it becomes a measure of the degree of mastery of the Recall-Translation phases of the Learning Process model. The Post-administration of this test provides a measure of additional learning in this area done during the field experience.

Individual Growth and Benefits from Program

Each student and facilty sponsor have a unique experience on Kentucky January. Thus each participant grows in a special way and gains unique benefits from the program. This information is not quantifiable, but it is of great value. It is expected that each participant will achieve the program goals, but it is also recognized that the effects of this program go beyond the program goals. Thus it is necessary to learn the broader, more personal effects of Kentucky January.

Three methods are used to gather this information. First, in section V of the Open-Ended forms each person is asked to share what he gained as an individual. Second, the program staff spends time in the field talking with students, faculty, and people in the community to gain a "gut level" feeling for the impact of the program. Third, one student from each team is selected to represent that team on a panel discussion. The panel discussions are video taped and are kept on file at the University of Kentucky Medical Center. In these ways data is gathered regarding this highly subjective area. This information is used to give depth and reality to the more limited objective data.

TABLE 2

EVALUATION GOALS AND STRATEGIES FOR GROUP DEVELOPMENT

Evaluation Goal	Evaluation Strategy
1. Did the students and their Faculty Sponsor develop into a functioning group.	Group Effectiveness Scale
2. Was the attitude of the students during the program positive with regard to the program goals and their group.	Climate Gauge
3. What was the climate of cooperation, communication and interaction in the group with regard to team issues and problems of team functioning.	Team Final Report (part I.C.)

TABLE 3

EVALUATION GOALS AND STRATEGIES FOR ENVIRONMENTAL ORGANIZATION

Evaluation Goal	Evaluation Strategy
1. What scheduled meetings/activities were attended?	Fall Activities Form
2. Were the Recall-Translation blocks of the learning process model taught/learned in the Fall?	Fall Activities Form, Pre Administration of the Recall Test.
3. During the Fall were plans made and research done for the in-field site visits?	Fall Activities
4. What teaching aids were used and how useful were they?	Teaching Aid Evaluation Checklist
5. Should any of the activities or procedures be revised, deleted or replaced?	Open Ended Form - Student, (parts I & II), Faculty (parts I & II), Location Coordinator (parts I, II & IV)
6. Should the Faculty Sponsor's function be revised?	Open Ended Form - Student (part III), Faculty (part III)
7. Should the arrangements for food, lodging, or transportation be revised.	Open Ended Form - Student (part IV), Faculty (part IV)
8. What did the Location Coordinator do that contributed to the program.	Location Coordinator (part III)

Data Analysis Plan

Four distinct types of analysis that are used: 1) change, 2) tabulation, 3) growth, and 4) content analysis. The type of analysis is determined by the nature of the evaluation goal measured by the instrument.

Change analysis, repeated measures analysis of variance, univariate and multivariate, is used on the instruments that were administered on a pre-to-post basis. This includes the Recall Test, Health Care Environment Test and Health Professions Attitude Survey.

Tabulation of comments by frequencies is done for the Fall Activities Form, Open-Ended Forms, and Teaching Aid Evaluation Checklist. Typical cross-tabulation variables are sites, professions, clinical vs. observational teams, and rural vs. urban sites.

Growth analysis using stochastic modeling procedures is used for the Group Effectiveness Scale and the Climate Gauge. Markov Chains is used for the Group Effectiveness Scale and simple state plotting is used for the Climate Gauge.

Content analysis is performed on the Team Final Reports. This is done by using the objectives the reports were designed to evaluate and rating each report as to its coverage of the objectives.

Conclusion

This paper has discussed a philosophy of using process models to aid in the development of educational programs. An example of how this philosophy can be applied to an actual program in Health Professions Education has been presented. Three kinds of models were discussed; what people learn, how people learn, and where people learn. These three models are appropriate for any program, however they are not meant to exhaust the possible models that my be utilized.

The strength of this approach lies in the utility of the models to assist the program developer in visualizing the program. The models provide a bridge between the program goals and objectives and the teaching sequence. Also, the models provide a framework upon which the objectives, teaching sequence, and evaluation design can be logically arranged and related to each other.

AN ANALYSIS OF INTERACTION OF ANXIETY, ASPIRATION LEVEL AND ABILITY DERIVED FROM ECOLOGICAL SYSTEMS THEORY

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Calgary, Alberta, Canada

Introduction

A technique for analysis of ecosystems developed by Odum (1971) has met with considerable success as an empirical predictor of system behavior. The focus of this technique is on the nature of interactions which take place within the system being considered. Variables within the system are dynamic over time, while influences from outside the system are either fixed, or vary in a predetermined fashion and are not affected by the behavior of the system being considered. The nature of interactions within the system are governed by the laws of thermodynamics, conservation and entropy, which provide guidance from well understood physical principles as well as providing a transition to mathematical representation of the interactions. The use of these principles is currently being applied to information theory (Gatlin, 1972) and economic theory (Georgescu-Roegen, 1975).

In this procedure, a system is defined as a collection of dynamic variables and the interactions between these variables which produce changes over time. Variables outside this framework, which influence the system but which remain unchanged by system behavior, are termed forcing functions. Thus, the system is defined to include those variables within the system as dynamic, if attention is to be focused on these variables and their interactions, and not on possible changes which may occur in forcing functions which interact with the dynamic variables, but whose behavior is predetermined. Variables within the defined system which remain constant over time are not specified. In calculations involving thermodynamic principles, variables which are constant are not included in the calculations. Therefore, these variables are not included in the definition of the system. Should other variables which were considered as constants actually prove to be dynamic, the system will not function adequately unless the variables are included.

Interactions which take place among variables and forcing functions may involve variations which result from linear or inverse, additive or multiplicative interactions or by interactions which can be represented by trigonometric functions and/or a combination of all types. Therefore, any system for which information exists as to dynamic variables, forcing functions and their interactions can be defined and investigated. Whether or not the system duplicates known variations is then determined by whether or not interactions taking place within the system are correctly defined.

Definite principles determine the nature of interactions and boundary conditions for such interactions. These principles are derived from thermodynamics, but the most important ones may be restated to be more applicable to social science investigations. A conservation principle operates which defines boundaries for interactions. This principle indicates that the sum of all contributions of all variables to an interaction must be equal to the sum of all the results of the interaction, plus any losses which occur during the interaction.

A second principle, entropy, refines the conservation principle. This principle states that the sum of the products must always be less than the sum of the contributions, that is no interaction is perfect. Some loss is always associated with an interaction although this loss may be very small. This loss is in proportion to the difficulty encountered in achieving the interaction. Given two stimuli, one visual and one auditory, interacting with one another so that the result is additive. The first principle of entropy limits the resulting interaction to the sum of the two stimuli. The second principle of entropy reduces the result by some quantity, making the result of the interaction of the two stimuli greater than either stimulus alone, but not equal to the sum of the two.

A third principle is a maximizing principle, which states that interactions are maximum over time if the sum of products of the interactions is 50% of the sum of contributions to the interactions. Intermediate levels of motivation are optimum and optimum achievement activity occurs at intermediate levels of probability of success. The interaction of student and learning material may well be maximized at intermediate levels. If a student interacts with simple material, the result is diminished because much of the interaction is hasty and material is ignored. Material which is too difficult results in diminished interaction as well, though for different reasons. Maximum interaction over time occurs with materials of intermediate difficulty. Perhaps, this principle explains to some extent, one of the shortcomings of programmed material in which the steps are too small. It must be noted that this refers to maximization over time, not to maximum instant results. Maximization over time results from interactions which are neither too easy nor too difficult to attain.

A final major principle is a depreciation principle. This principle states that all dynamic variables require maintenance, or, conversely, if the variable does not interact over time, it depreciates. Unless information is used, it depreciates exponentially over time. Maintenance of information counteracts depreciation resulting in longer retention. Depreciation is also dependent on the magnitude of the stored quantity. More storage requires more maintenance.

Because these principles are based on known physical laws which can be represented mathematically, the model of a system derived from these principles may also be represented mathematically. The contribution of any variable to an interaction is determined by the magnitude of the variable and the interaction which takes place. In some cases, the variable contributes to the interaction; in others the variable is influenced by the result of an interaction or several interactions. Each

of the contributions the variable makes to an interaction can be represented by a mathematical relationship determined by the nature of the interaction. The same can be done for each contribution made to the variable as a result of an interaction. With this information, each dynamic variable in a system can be represented by a differential equation which is a sum of all contributions to the variable minus the sum of all contributions of that variable to interactions within the system. Simultaneous integration of all these equations over time provides data on changes of each variable over time, and thus data on behavior of components of the system.

Several advantages accrue from this technique. If data from the model duplicate known data, integration over longer periods of time provides predictions about system behavior in time frames which go beyond the original data. Constants in the differential equations, called transfer coefficients by Odum (1971), indicate the magnitude of the contribution of each variable to an interaction. The reciprocal of a constant is a time constant. This indicates the time required for one complete interaction in relation to other interactions. Finally, it is possible to investigate a wide variety of conditions within a system by beginning with different initial conditions for variables. Thus, many hypotheses can be tested to determine those facets of a system which are most crucial to system behavior and might provide information concerning those hypotheses which would yield the most significant results when empirical investigations are conducted.

Achievement Theory

Achievement theory, as propounded by Atkinson, is based on the assumption that subjective judgments about probability of success, or likelihood of attaining a goal, interact with perception of task stimuli to produce a specific kind of response. It is this postulated interaction or mediation which permits labeling of Atkinson's theory as a cognitive, or at least a quasi-cognitive, one.

Briefly, achievement theory can be summarized as follows:

1. According to Murray (1938), an organism responds to the environment because of needs which may be labelled as potentialities to respond. The environment may be supportive or it may act to block action. Since an organism acts in specific and voluntary ways in response to a perceived situation, it follows that the organism is being active in making choices, and the overall way in which it makes such choices can be viewed as a personality characteristic.

2. McClelland(1951) refined the work begun by Murray, emphasizing the role of motivation in behavior. McClelland saw motives as being based on emotions which resulted from association between stimulus situations and affective states. Thus, anticipated goal reactions initiate and direct behavior through aroused needs. Since such needs fluctuate in intensity, it follows that optimal levels of aroused needs

can be postulated. An organism will then act both to reduce needs above optimal level and to increase incoming stimulation if it drops below a certain level.

> This motivational tendency refers to the positive or negative anticipatory goal reactions aroused in situations that involve competition with a standard of excellence, where performance may be evaluated as a success or a failure. (Weiner, 1972, p. 175)

3. Methods used for arousing and measuring the needs for achievement are well known. The Thematic Apperception Test, developed by Atkinson, is used to obtain protocols describing the content of thought. Experimental procedures increase and decrease perceived estimates of the probability of success, anxiety and achievement. Posttest results are analyzed to determine the effects of interactions among these variables.

4. Atkinson (1957) attempted to specify statistical relationships related to achievement theory and to relate these relationships, in turn, to individual differences in achievement needs and their effect on motivation. In addition to person, environment, and experiential variables, Atkinson also investigated conflicts associated with choice behavior (Weiner, 1972).

> Further, Atkinson's theory of achievement motivation is influenced by Miller's conflict model. Achievement-related behavior is conceptualized as a result of a conflict situation. It is assumed that the cues associated with competition against a standard of excellence arouse both the hope of success and the fear of failure. The strength of the approach tendency toward the goal, the hope of success, relative to the strength of the avoidance tendency, the fear of failure, determines whether the individual will locomote toward or away from achievement-related tasks. (p. 195)

5. The tendency to approach or avoid an achievement-oriented activity can be summarized as:

$$T_A = (M_S - M_{AF}) \left[P_S \times (1 - P_S)\right]$$

Here $T_A = T_S + (-T_{AF})$ or the tendency to approach the task plus the tendency to avoid the task;

M_S equals motivation to succeed;

M_{AF} equals motivation to avoid failure; and

P_S equals the perceived probability of success.

Measures of these variables are converted to Z-scores to make intra- and inter-individual comparisons possible. The theoretical question is whether or not these determinants are a sufficient basis on which to account for need-related behavior.

6. Weiner (1972) proposed that by assigning weights to the determinants of behavior a model can be tested against empirical data. Additional variables of Risk Preference, Level of Aspiration and Persistence of Behavior in Progress can also be tested.

7. M_S and M_{AF} are considered to be relatively stable personality traits, while incentive values of the goal are dependent on P_S. Thus, future actions are almost entirely dependent on effects of success and failure, or on P_S which is the only variable that is free to fluctuate from trial to trial and which can therefore be classified as an experiential variable, that is, it depends, in part at least, on an individual's history of success.

8. Studies which have attempted to use the basic model outlined in statement 4 have been unable to accommodate effects of the history of success and failure associated with P_S. In order to make the model fit empirical data, Atkinson and Cartwright (1964) introduced an additional variable which they described as the inertial tendency or the unsatisfied tendency to persist in achieving a goal (T_{Gi}). Thus a general tendency to achieve a goal may be added to the need to achieve, and this additional energy affects the subsequent motivation to achieve success. Thus:

$$T_S = (M_S \times P_S \times T_S) + T_{Gi}$$

Given the complexity of the relationship among determinants of need-achievement behavior, it becomes obvious that simple models will not produce adequate solutions. It is nevertheless of interest to produce models which will account for behavior and which will match well empirical findings reported in this area. If a model, using the determinants described in the achievement model, can be structured so as to reproduce empirical data, then some measure of validity will accrue to the achievement model. Furthermore, the question of optimality will become more meaningful because effects of changes in any of the determinants of need-related behavior can be predetermined.

In order to test this assumption and the validity of such a model, data were selected from a research study reported by Feather (1966). A brief summary of this study is presented here.

Feather noted that effects of success and failure on subsequent performance were extremely complex, depending on characteristics of the person and on the situation. In order to facilitate disentanglement of determiners of action, Feather divided subjects into four groups as follows:

1. High expectation - initial failure (H-F). Instructions induced a high initial expectation of success. These subjects were then given five items which were insoluble followed by ten items at a .50 level of difficulty. The assumption was made that failure on the first five items would reduce P_S to .50.

2. Low expectation - initial failure (L-F). In order to induce a low expectation of success, instructions implied that the subjects would

find the items difficult. Thus five insoluble items were followed by ten items at the .50 level of difficulty. Prior failure should have the effect of lowering P_S.

3. High expectation - initial success (H-S). Subject instructions implied that the tests would be easy. Thus five easy items were followed by ten items at a .50 level of difficulty. The assumption was that initial success should raise P_S even more.

4. Low expectation - initial success (L-S). The conditions were as in 3 above except that subjects were informed that the test items were difficult. Initial success should result in a rise of P_S to .50.

The conditions arranged by Feather were intended to elicit data about effects of these four experimental conditions on subjects' performance and the relationship of this performance to differences in achievement and test anxiety. Thus initial success and failure should result in changes in the tendency to perform the task. According to Feather (1966) this tendency consisted of a total motivation made up of a tendency to achieve success, a tendency to avoid failure, and extrinsic motivation.

> Among subjects in whom $M_S > M_{AF}$ the resultant tendency to perform the task is maximum when $P_S = .50$. Among subjects in whom $M_{AF} > M_S$ the resultant tendency to perform the task is minimum when $P_S = .50$. Thus, in contrast to Atkinson's earlier position (Atkinson, 1957), the present assumptions do not imply that a subject in whom $M_{AF} > M_S$ should try hardest when $P_S = .50$. On the contrary, because of the strong inhibitory tendency to avoid undertaking the task when $P_S = .50$, the resultant tendency to perform the task would be at a minimum for such a subject. (p. 288)

Using these basic assumptions, Feather stated the following hypotheses:

1. Where $M_S > M_{AF}$ the resultant tendency to perform after the first five items will be stronger in the H-F and L-S conditions. This tendency should remain at a high level because the remaining ten items were at .50 level of difficulty and therefore close to the values developed during initial trials.

2. Since it is assumed that higher resultant tendency determines superior performance, it can also be postulated that this group should obtain higher scores on the last ten items.

3. Where $M_{AF} > M_S$ the resultant tendency to perform the task after the first five items will be greater for the L-F and H-S groups.

4. These two groups should also be relatively less successful.

By using a series of items it was possible to study changes in expectations over time. The questions of interest raised in this study are summarized by Feather (1966) as follows:

> Do estimates of expectation of success change more rapidly after failure than after success? Is the rate of change a function of the initial estimate of expectation of success, of Achievement, and of Test Anxiety? Are there differences between subjects in the degree to which "typical" changes in probability estimates occur after success and failure? (p. 289)

The subjects in the study were 96 female undergraduates. Subjects completed protocols for six of the Achievement pictures and the TAQ. The scores on these tests were converted to Z-scores and the difference between the two calculated for each S. In S's for whom this difference was positive it was assumed that $M_S > M_{AF}$; for those which were negative, it was assumed that $M_{AF} > M_S$.

The criterion test used in the study consisted of a series of 15 anagrams. For the H-F and L-F groups the first five anagrams were insoluble; for the H-S and L-S groups the first five were very easy. For all groups the remaining ten items were rated as being at the .50 level of difficulty. Instructions varied as indicated above.

Table 1 presents the mean of the probability estimates obtained from subjects prior to attempting each of the anagrams. An analysis of variance of these data was also conducted by Feather. It demonstrated significant effects due to initial experience and an interaction between initial experience and trials.

Table 1

Mean Estimates of Probability of Success for Anagrams over 15 Trials *

Group	Trials														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
H-F															
Success oriented (N = 9)	.61	.49	.41	.31	.13	.16	.27	.31	.28	.31	.32	.24	.27	.34	.35
Failure oriented (N = 9)	.70	.53	.38	.30	.22	.21	.29	.36	.51	.45	.52	.42	.43	.49	.49
L-F															
Success oriented (N = 9)	.56	.49	.38	.35	.29	.23	.33	.33	.35	.33	.31	.35	.33	.34	.35
Failure oriented (N = 9)	.55	.36	.28	.19	.15	.15	.18	.19	.26	.19	.23	.23	.24	.36	.31
H-S															
Success oriented (N = 9)	.67	.66	.69	.74	.75	.79	.68	.72	.69	.70	.68	.67	.63	.64	.63
Failure oriented (N = 9)	.54	.58	.66	.70	.71	.68	.66	.60	.53	.53	.56	.56	.56	.56	.55
L-S															
Success oriented (N = 9)	.50	.63	.66	.74	.74	.78	.70	.60	.59	.61	.57	.60	.59	.55	.50
Failure oriented (N = 9)	.57	.62	.70	.76	.78	.80	.69	.75	.74	.65	.70	.69	.68	.69	.64

*Adapted from Feather (1966, p. 290)

Table 2 presents information about the mean number of anagrams correctly answered out of the final ten anagrams. An analysis of variance of these results indicated that initial experience had a significant effect of performance.

Table 2

Number of Subjects Solving Anagrams on Trials 6-15 *

Group	Trials									
	6	7	8	9	10	11	12	13	14	15
H-F										
Success oriented (N = 9)	4	4	5	4	3	0	3	5	5	2
Failure oriented (N = 9)	5	5	5	5	7	3	4	3	5	3
L-F										
Success oriented (N = 9)	5	5	3	1	4	5	2	6	2	5
Failure oriented (N = 9)	2	6	7	1	9	5	6	7	4	4
H-S										
Success oriented (N = 9)	5	5	5	6	7	6	3	7	4	6
Failure oriented (N = 9)	5	3	5	5	7	6	6	5	4	6
L-S										
Success oriented (N = 9)	4	6	7	6	4	7	4	7	6	4
Failure oriented (N - 9)	5	6	6	3	7	8	7	6	4	6

*Adapted from Feather (1966, p. 294).

Several other analyses were conducted by Feather. In this case, however, the interest is mainly in probability estimates and actual achievement and the way in which they interact as a system.

Feather pointed out that the major contribution of the report lies in the fact that a detailed analysis of probability estimates was made during the entire course of student responses. He also noted that the findings lend support to the belief that success and failure play a significant role in shaping estimates of probability of success and, thus, in expectation of success. He also noted that:

1. Probability estimates change more after failure at the first five items than after success at the first five items, suggesting that consistent failure has a greater effect than consistent success when initial expectation is intermediate.

2. Success-oriented subjects tend to make more typical changes in P_S estimates under conditions of success while failure-oriented subjects make more typical adjustments under failure conditions. All of this may, of course, be related to past experience or inertial tendencies discussed above.

3. Since this study was limited to eliciting P_S estimates from only one trial to the next, it is limited in terms of generalizability to situations in which trial-to-trial expectations are somewhat independent. S's were not asked to predict their changes of attaining a fixed performance level. On the other hand, the results obtained appear to conform to those found in other studies which looked at the effects of success and failure on expectations of success.

4. Initial experience has a significant effect on performance when S's are given feedback regarding success and failure. As in any experiment, it is difficult to generalize the results because the number of success and failure experiences required for long-term increments and decrements in achievement patterns for the various groups did not conform to expectation. For example, Table 1 shows that the mean scores on performance in the initial failure condition are higher than those for failure-oriented subjects. It is not clear why this should be the case, and it may be that the models being used are not sufficiently developed to account for this anomaly.

5. Instructions given at the beginning of a series of tasks tend to set the general difficulty of the tasks at the outset so that P_S tend to cluster about a certain value depending on the instructions. Previous research also indicates that performance is related to this general level of difficulty because S's work harder when their expectation of success is intermediate. If the difficulty of the task is truthfully represented, task performance and initial probability tend to be correlated. In addition, S's tend to draw upon past experiences and to make judgements accordingly. This has the effect of anchoring them to reality so that fluctuations about the mean in terms of estimates of probability of success, level of aspiration and responses to success and failure are kept within reasonable bounds.

The Modeling Procedure

Data from the Feather study were examined to determine how achievement (A) and probability of success (P) varied over time for each treatment group. Both A and P were plotted against the number of trials in each instance. As well, the number of successive trials during which P or A continued to change in the same direction and the number of trials before the trend reversed was examined and the results pooled for all eight groups. P was found to change an average of .07 in a positive direction and an average of .07 in a negative direction in 1.74 trials. A was found to change an average of 38% in a positive direction and 35% in a negative direction in 1.70 trials. Further, the change in P was opposite in direction to the change in A at any time. For purposes of the model, P was taken to change 0.10 in two trials and A 40% in two trials. The time taken in the Feather study was estimated at two minutes per trial because 15 anagrams were to be completed in 30 minutes.

The following interactions and their relationships were incorporated into the model of this system:

1. Probability of success and incentive were represented as hypothesized by Feather, or as P x I·(P x (1-P)).

2. Incentive and probability of success interact with motivation as hypothesized, or M x P x (1-P).

3. The additional effect of persistence of previous achievement activity or inertial tendency adds an inverse variation component to the interaction of M x P x (1-P). This relationship derives from Feather's data mentioned previously.

4. Probability of success at time t + 1 is directly proportional to the magnitude of achievement and probability of success at time t.

The system and interactions which occur within the system are shown schematically in Figure 1. The symbols are from Odum (1971).

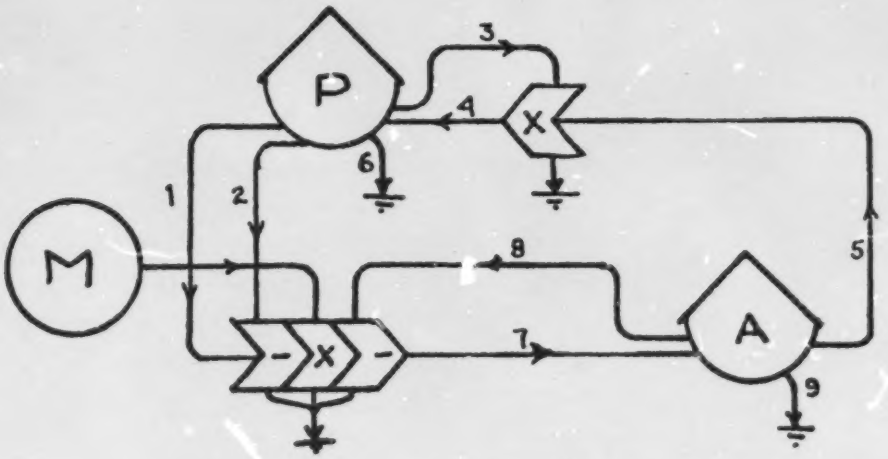


Figure 1

The dynamic variables are shown with tank-like structures; the interactions by arrows; and the contribution to and products of interactions shown by lines. Interactions in which variation is direct are shown with a' x ' and inverse variations with a' - '. Motivation (M) is considered outside the system, that is, it is considered a relatively stable personality characteristic and for purposes of the model does not vary over time. The numbers on each line indicate the number of the constant associated with the contribution or product and will also be used to identify these.

In translating the symbolic representation of this system to a useable mathematical form, the following conventions are followed:

1. The magnitude of a variable can assume values between zero and one. In other words, the magnitude of the variable is always represented as a proportion of the maximum possible magnitude.

2. By using convention #1, inverse variation can be represented mathematically as one minus the magnitude of the variable which varies inversely.

3. The contribution of any variable to an interaction, or effect of the result of an interaction is dependent on the magnitude of all interacting variables. Thus an interaction of A and P in which the relationship is a direct variation would be A x P. The actual magnitude of the contribution or product is modified by a constant, termed an interaction coefficient. Therefore, several interaction contributions may have the term A x P but these differ when the interaction coefficient is considered. The coefficient has two functions - first, it indicates the magnitude of the total possible contribution or product, and second, its reciprocal is a time constant. The time constant indicates the relative time period for one complete cycle.

4. Constants 6 and 9 are associated with depreciation of the variable over time. This depreciation depends only on the magnitude of the variable. The reciprocal of the constant indicates how long it would take for the variable to depreciate to zero if there is no maintenance of the variable.

Table 3 shows each of the contributions or products and how each is represented mathematically.

Table 3

Mathematical Representation of
Contributional Products

Constant #	Representation	Description
1	k_1 M(P)(1-P)(1-A)	contribution of probability of success
2	k_2 M(P)(1-P)(1-A)	contribution of incentive
3	k_3 PA	contribution of P to change in P
4	k_4 PA	product of interaction of P and A
5	k_5 PA	contribution of A to change in P
6	k_6 P	depreciation of P
7	k_7 M(P)(1-)(1-A)	product of interaction of M, P, incentive & A (inertial tendency)
8	k_8 M(P)(1-)(1-A)	contribution of A to interaction of M
9	k_9 A	depreciation of A

The mathematical representation of the system is accomplished by developing a differential equation for each variable. This equation is a sum of all the products which contribute to the variable minus the sum of all contributions the variable makes to interactions and the depreciation of the variable. The two differential equations representing this system are:

$$P = k_4PA - k_3PA - k_1 M(P)(1-P)(1-A) - k_2 M(P)(1-P)(1-A) - k_6P$$

$$A = k_7 M(P)(1-P)(1-A) - k_8 M(P)(1-P)(1-A) - k_5PA - k_9A$$

If these equations are integrated simultaneously from zero to time t, the result is a plot of the changes of the variables during time t. The procedure has been to use an analog computer to do this. However, digital computers can be used if the equations are rewritten as:

$$P_{t+1} = P_t + i \left[k_4P_tA_t - K_3P_tA_t - k_1M_t(P_t)(1-P_t)(1-A_t) - k_2 M_t(P_t)(1-P_t)(1-A_t) - k_6P_t\right]$$

$$A_{t+1} = A_t + i \left[k_7M_t(P_t)(1-P_t)(1-A_t) - k_8M_t(P_t)(1-P_t)(1-A_t) - k_5P_tA_t - K_9A_t\right]$$

where i is some time interval. It must be noted that i must be kept small in order to achieve accuracy in most cases.

Because the constants are time dependent and to date, no feasible technique has been developed for relating raw data to the constants, an alternative is to search for the constants and to refine these by successive approximation. This is possible because the behavior of the variables is understood for some time period at least.

A computer program, using the equation for digital machines, can be written to solve for P and A by successive iterations and given the initial values for P, A, and M. The time increment should be kept small, approximately .05 in this case, as accuracy increases with small values of i. In this case, approximately 40 iterations would be necessary to cover the two minute time span. The program can be adopted to test all values of all combinations of constants in steps of .10 for each constant. In order to reduce the amount of computer time A and P should be checked after each iteration. If either value is greater than 1 or less than zero, the constants used for this iteration are incorrect and no further iterations are useful. When a solution is attained, it should be subjected to more iterations to assure that it remains viable over time, otherwise further refinement is necessary.

It was found that the solutions obtained have a unique set of constants. Some adjustment of the constants is necessary in order to obtain the proper range of oscillation of the variables or to assure that the variable level at the proper magnitude. In this respect, an analog computer is easier and faster to work with, but still not a requirement. If no feasible solution is reached when all combinations

of constants have been tried, i should be decreased because variables may be fluctuating very rapidly and an increment in time (i) which is too large would not allow equations to respond adequately.

It should also be noted that multiples of constants also provide a solution, that is, if all constants are multiplied by 2, for example. Determination of the constants which apply to the model can best be ascertained by taking the reciprocal of the constants to obtain the time constant. These can be checked to see if they are reasonable. For example, the time for depreciation of variables should be reasonable. If these are too large or too small by some factor, all constants should be adjusted by that factor.

Discussi

Theoretical Implications

In order to understand some of the information derived from the model, a more detailed discussion of the interaction coefficient and the time constant may be beneficial. These two values are dependent on the nature of the variables which interact or are affected by the interaction and also on the nature of the contributions or products themselves.

The time constant is dependent on the capacitance of the variable concerned and the resistance encountered in contributing to an interaction or in affecting a variable or $T = RC$. Capacitance in a social science context is a measure of the amount of input which can be accommodated over a period of time and is inversely proportional to the difficulty in achieving integration of the input. The resistance is the difficulty encountered when a variable contributes to an interaction or the difficulty encountered in utilizing the product of an interaction. In either case, the difficulty is determined by the nature of the interaction taking place. The time constant, then, is an indication of the time required to produce some specified amount of change, given the nature of the variable's ability to accommodate interaction within the system and the difficulty in achieving interactions. Thus if the specified amount of change is 20%; all of the time constants, when compared to each other, indicate the ratios of times required to produce such a change. The interaction coefficient is the reciprocal of the time constant, and while this value is required for the equations in the model, it is the time constant which provides the critical information.

Table 4 presents interaction coefficients which correspond to the interactions and products indicated previously in Table 3 and in the schematic diagram of the system. Also, time constants are shown and the ratio of each time constant to the smallest time constant, time constant #7.

Table 4

Constants for the System

Number	Interaction Coefficient (k)	Time (T) Constant	T_i/T_7 (Approximate)
1	6.80	0.15	3
2	6.80	0.15	3
3	2.72	0.37	7
4	4.44	0.23	5
5	1.15	0.87	16
6	0.70	1.43	29
7	20.00	0.05	1
8	1.10	0.91	18
9	0.01	100.00	2000

The coefficients duplicate with some qualifications, the results obtained by Feather (1966) for those conditions which applied to the individuals used for that study. Plots of the change in P and A over the series of trials conducted by Feather (1966) do not result in a series of smooth curves as is the result from the model. This is to be expected since the sample in the Feather study was quite small. However, the nature of the changes are duplicated for the different conditions as are the magnitudes of the fluctuations. It can be seen that the fluctuations decrease as the number of trials increase, as was the case in the Feather (1966) study, and that the ultimate leveling of P and A occurs at a value corresponding to the mean for that sample. With a large sample, curve fitting techniques could be applied to the raw data to achieve plots which are regular and thus determine precise reliability of the results obtained from the model.

A number of the plots shown in Figure 3 apply to situations which did not exist in the model. These are values for P, A, and M which did not exist in the sample but for which predictions could be made from achievement theory. In these cases, the results from the model do correspond with predictions.

Examination of the ratios of various time constants provides some useful information. When the contribution of P to future changes in P, constant 3, are compared to the contribution of A, constant #5, to this change, the ration of T_5 and T_3 is about 2:1. This indicates that changes in P are more readily affected by the magnitude of P than the magnitude of A. In other words, changes in P are facilitated more easily by manipulating P rather than A. Given the nature of P and A and the nature of the interaction, the utilization of changes in P to produce changes in P over time proceeds more readily than attempting to change P over time by changing A.

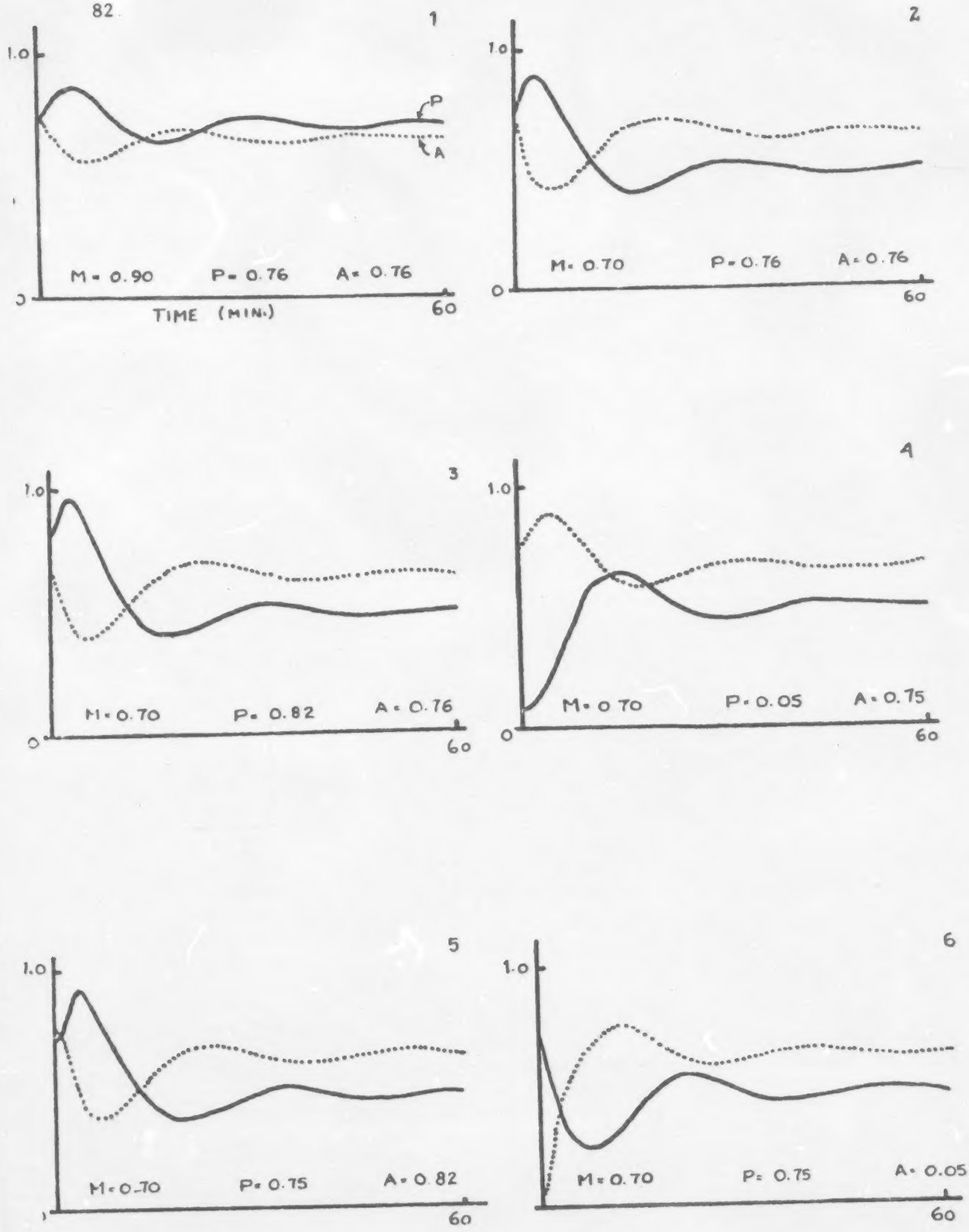

1
1.0
P
A
M = 0.90 P = 0.76 A = 0.76
0
TIME (MIN.)
60
2
1.0
M = 0.70 P = 0.76 A = 0.76
0
60
3
1.0
M = 0.70 P = 0.82 A = 0.76
0
60
4
1.0
M = 0.70 P = 0.05 A = 0.75
0
60
5
1.0
M = 0.70 P = 0.75 A = 0.82
0
60
6
1.0
M = 0.70 P = 0.75 A = 0.05
60

Figure 3a

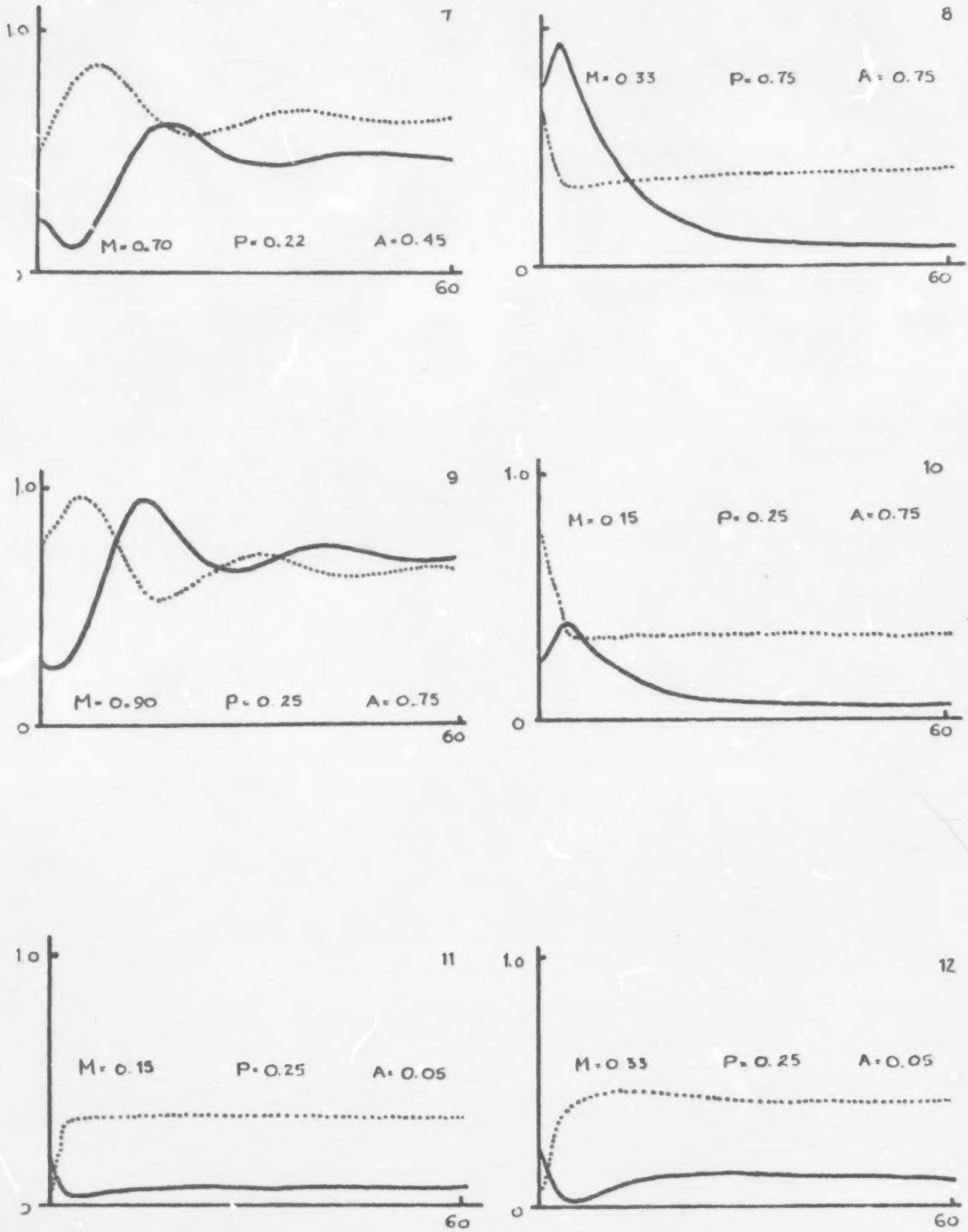
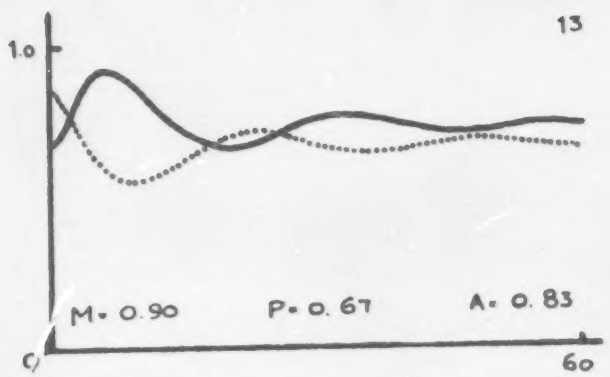
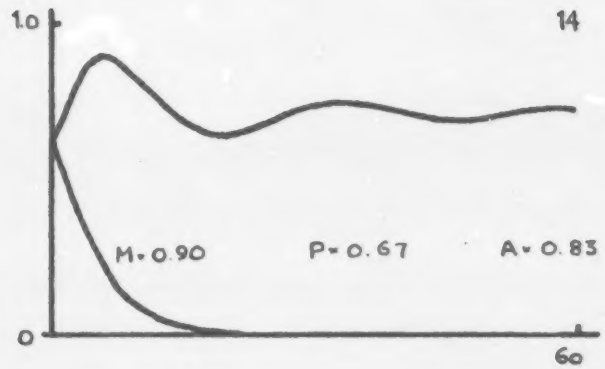
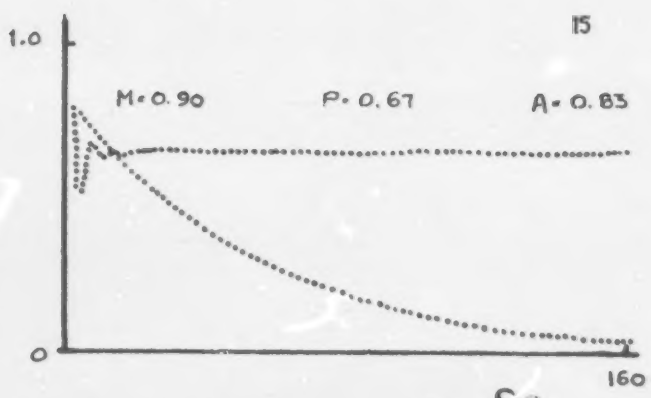

7
1.0
M= 0.70
P= 0.22
A= 0.45
60
8
M= 0 33
P= 0.75
A = 0.75
0
60
9
1.0
M= 0.90
P= 0 25
A= 0.75
0
60
10
1.0
M= 0 15
P= 0.25
A= 0.75
0
60
11
1 0
M= 0. 15
P= 0.25
A= 0.05
0
60
12
1.0
M= 0 33
P= 0.25
A= 0.05
0
60

Figure 3b


13
1.0
M= 0.90
P= 0.67
A= 0.83
0
60


1.0
14
M= 0.90
P= 0.67
A= 0.83
0
60


1.0
15
M= 0.90
P= 0.67
A= 0.83
0
160

89

Figure 3c

The magnitude of T_8, the inertial effect of achievement, when compared to the magnitude of T, probability, and T_2, incentive, in achieving the interaction necessary for increases in achievement, indicate the longevity of the inertial effect. The depreciation of P, or the rapidity with which it decreases if not maintained, indicates that P is most task-specific and changes very rapidly. Using graph #14 in Figure 3, which is a plot of the behavior of P when maintained and not maintained, the indication is that P would be reduced to half its value in about two minutes. The reverse is true of A. Here the indication is that retention of achievement level is still 50% after approximately 30 minutes.

Psychological Implications

The advantage of using this model has already been noted. The question arises, however, as to whether or not such a model can represent empirical data faithfully, whether it fits existing theory, and whether it can give new psychological information or at least suggest research hypotheses which may lead to clarification of psychological principles. It is felt that all three of these aims can be encompassed.

First of all, an examination of the graphs presented in Figure 3 indicate substantial agreement between these results and the results obtained by Feather (1966). The results of the Feather study were not used to derive this model, but were used as an empirical validity check. Thus, it can be seen that probability estimates change more after failure at the first five items than after success. Success and failure also function to bring expectation and achievement into line. This is true, of course, only as long as motivation remains at a reasonable level. Initial experience has a strong effect on performance when subjects are given feedback in terms of success and failure. Finally, there is also evidence that task performance and initial probability are correlated. It was noted, however, that this model suggests that achievement is at its highest level when expectation of success and achievement are both at a relatively high level. This finding appears to be contrary to Feather's and needs further investigation.

Secondly, it was noted that the graphs in Figure 3 demonstrate the validity of achievement theory as it is currently understood. Thus, expectation of success interacts with achievement such that a balance is achieved between the two as long as motivation remains high. Furthermore, it can be seen that inertial tendencies operate to keep achievement up even when expectation of success is very low. It was also noted that feedback effects operate quite rapidly so that expectation of success is affected almost immediately after results have become available and estimates of probability of success adjust rapidly when feedback is given.

Finally, there are implications for further research. Numerous possibilities for further research present themselves, but some of the most salient can be noted here.

1. Psychologists have long referred to optimal conditions for the support of specific activities. For example, it is well established that anxiety and performance on tests have some optimal relationship.

Unfortunately, establishing optimal levels of anxiety creates a problematic situation because no acceptable measure is known. In the model presented, it is relatively simple to determine the effect of increasing any of the sources of input and thus predetermining the effects of increasing power in any one variable.

2. Expectation of success and error rate have frequently been the bases for study in relation to programmed instructional formats. There is some suggestion in this model that when achievement and expectation of success are too high, solutions become unfeasible. Further study is required to elucidate this problem. From the study by Feather (1966) data could not be used in this case because the subjects used formed a group which was too homogeneous. Collection of further data with more heterogeneous subjects to study this possibility is intended.

3. A number of other psychological relationships can be investigated by the use of this model. The creativity-intelligence dichotomy, personality correlates and learning, and even the heredity-environment issue may possibly be addressed in this way.

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AN INSTRUCTIONAL SYSTEMS TECHNOLOGY MODEL FOR INSTITUTIONAL CHANGE

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> The innovator makes enemies of all those who prospered under the old order, and only lukewarm support is forthcoming from those who would prosper under the new ... because men are generally incredulous, never really trusting new things unless they have tested them by experience.
>
> Niccolo Machiavelli

Strategy for Institutional Change

The strategy to manage educational change in the Continuing Education Division at Canadore College has been to encourage an eclectic approach that mixes or blends elements of the process of individualization and personalization. The final set of mix is decided upon to achieve the best or optimum combination of these elements for each student. This strategy recognizes that there is no one magic way to teach each student. The aim is to account for each student, instructor, administrator, and counselor as an individual.

The model for change at Canadore College is based upon instructional systems technology.

Definition of Instructional Systems Technology

There are several definitions of instructional systems technology but one that highlights all of the essential features is provided by the Commission on Instructional Technology:

> . . . a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication and employing a combination of human and non-human resources to bring about more effective instruction. (Hitchens, 1971, p. 101)

Many people claim that they are either using a systems-model or that they are taking a systems-approach to instruction. However, there is little evidence of this in practice. To state definitions is not enough. A systems approach demands analysis, synthesis, modeling, and simulation.

An Instructional Systems Technology Model

When the programs at Canadore College were first individualized in the fall of 1970, a simple model was constructed as depicted in Figure 1. The model was augmented by borrowing some of the items from the personalized education program model which has been employed at Oakland Community College. This model is presented in Figure 2.

The LOGOS language (Language for Optimizing Graphically Ordered System) and the process of anasynthesis (Silvern, 1969) were used to achieve sophisticated models that could assist in considering the complex relationships of the elements of individualizing and personalizing the programs. The more programs were individualized, the more the complex relationships became apparent. In order to effectively utilize anasynthesis, administrators, faculty, and paraprofessionals must learn the process and the language. This was accomplished at Canadore through a staff development program. This led to a team of persons who could implement the process of anasynthesis.

The Canadore Continuing Education Division Model for Innovative Individualized and Personalized Programs contains seven subsystems. The model is shown in Figure 3. The subsystems are:

(1.0) ANALYZE CURRENT MODEL

(2.0) IDENTIFY CRITERIA

(3.0) EVALUATE OLD MODEL

(4.0) DESIGN NEW MODEL

(5.0) RUN SIMULATIONS

(6.0) EVALUATE NEW MODEL

(7.0) IMPLEMENT NEW MODEL

Subsystem (1.0) ANALYZE CURRENT MODEL will be discussed in detail in this paper. The first step, in subsystem (1.0) is to analyze the current Canadore Continuing Education model. This required two steps. These are shown in Figure 4 as (1.1) and (1.2). In subsystem (1.1) the current functions are modeled and in subsystem (1.2) the model is analyzed. Subsystem (1.1) contains three subsystems:

(1.1.1) DRAW MODEL

(1.1.2) SIMULATE MODEL TO TEST IT

(1.1.3) EVALUATE MODEL 1:1 CORRESPONDENCE TO CANADORE CONTINUING EDUCATION SITUATION

In subsystem (1.1.1) a model of current functions is given. This model represents a snapshot picture of the way the College program is conducted. The model contains a description of all elements of

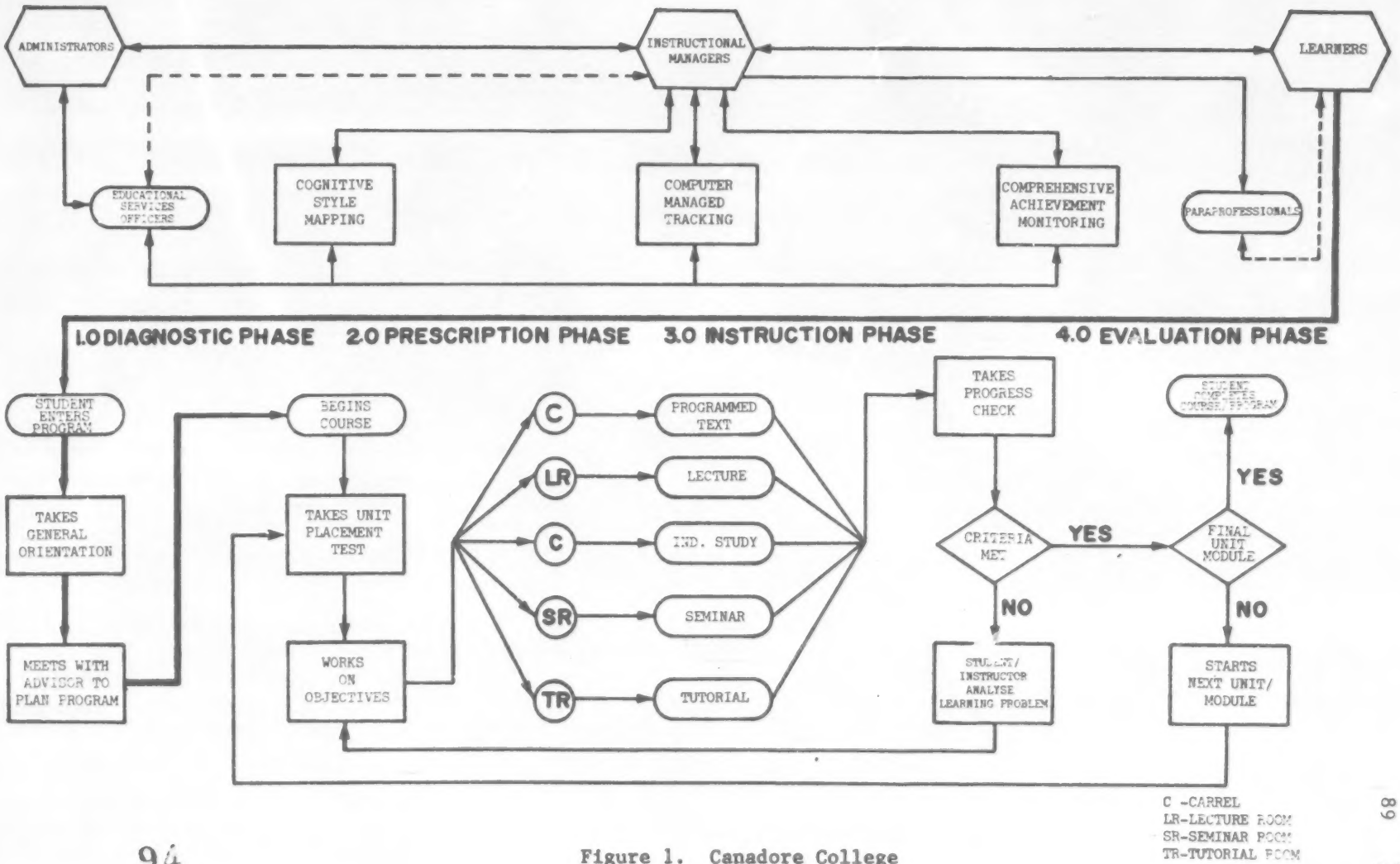
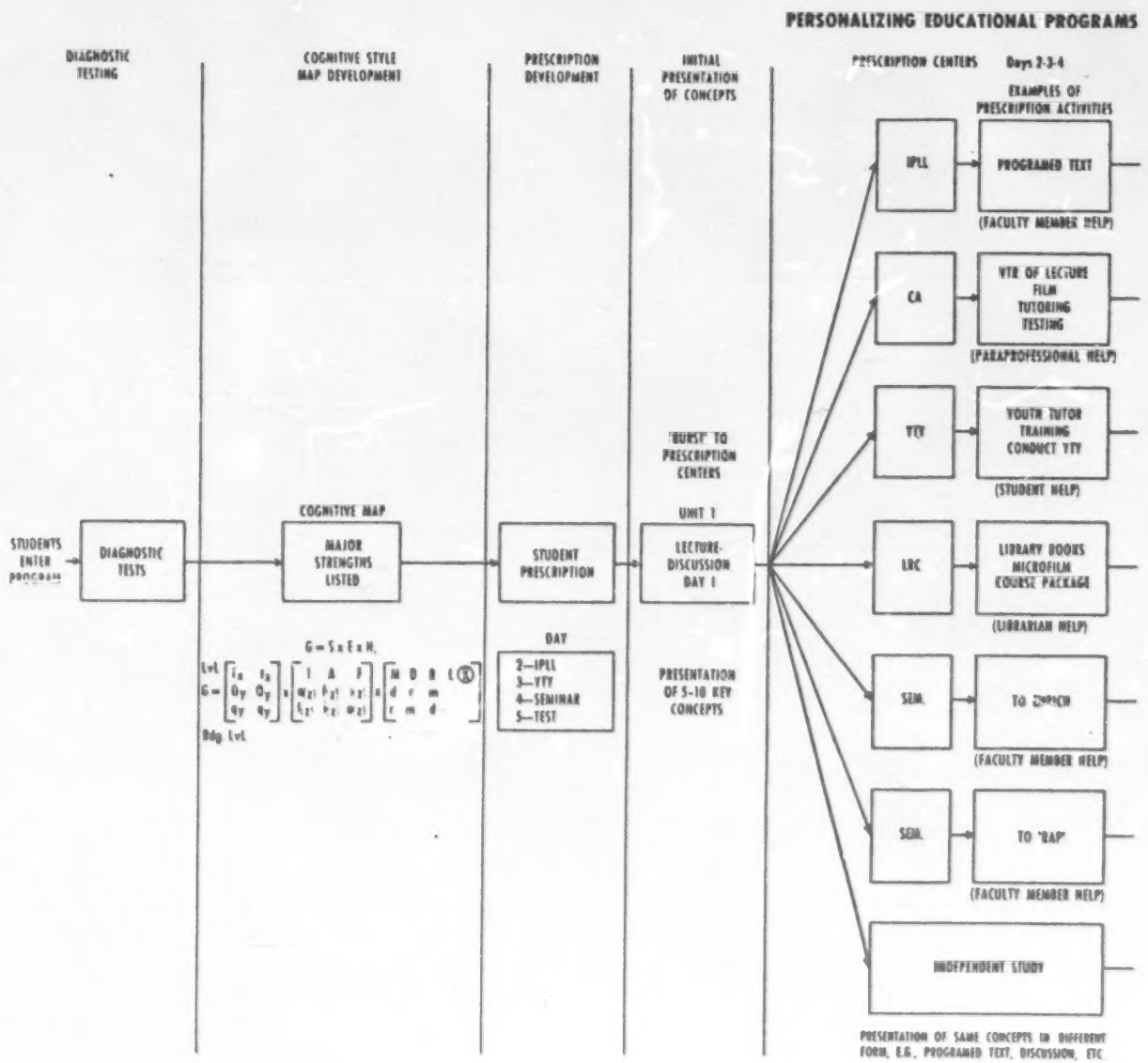


Figure 1. Canadore College

PEP

Flow Chart of Personalized Educational Program (PEP) Illustrating Student Progress From Diagnostic Testing Through Successful Completion of an Instructional Unit.



PERSONALIZING EDUCATIONAL PROGRAMS
UTILIZING COGNITIVE STYLE MAPPING

OCC
OAKLAND COMMUNITY COLLEGE

DR. JOSEPH E. HILL, PRESIDENT
DR. DEREK N. NUNNEY, VICE PRESIDENT

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Figure 2A

UTILIZING COGNITIVE STYLE MAPPING

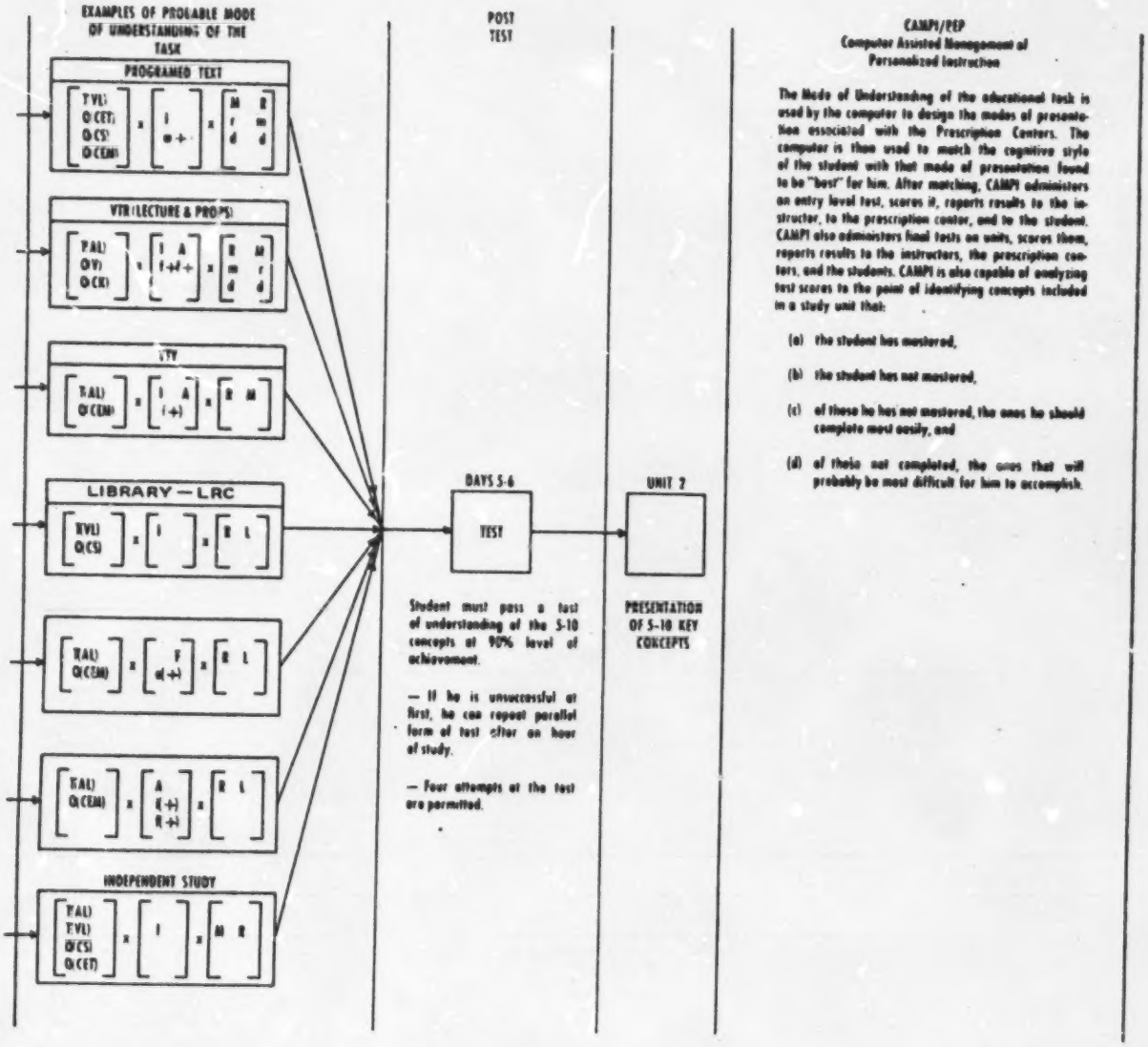

EXAMPLES OF PROBABLE MODE OF UNDERSTANDING OF THE TASK
PROGRAMED TEXT
VTR (LECTURE & PROPS)
VTR
LIBRARY — LRC
INDEPENDENT STUDY
POST TEST
DAYS 5-6
TEST
UNIT 2
PRESENTATION OF 5-10 KEY CONCEPTS
Student must pass a test of understanding of the 5-10 concepts at 90% level of achievement.
— If he is unsuccessful at first, he can repeat parallel form of test after an hour of study.
— Four attempts at the test are permitted.
CAMPI/PEP
Computer Assisted Management of Personalized Instruction
The Mode of Understanding of the educational task is used by the computer to design the modes of presentation associated with the Prescription Centers. The computer is then used to match the cognitive style of the student with that mode of presentation found to be "best" for him. After matching, CAMPI administers an entry level test, scores it, reports results to the instructor, to the prescription center, and to the student. CAMPI also administers final tests on units, scores them, reports results to the instructors, the prescription centers, and the students. CAMPI is also capable of analyzing test scores to the point of identifying concepts included in a study unit that:
(a) the student has mastered,
(b) the student has not mastered,
(c) of those he has not mastered, the ones he should complete most easily, and
(d) of those not completed, the ones that will probably be most difficult for him to accomplish.

Figure 2B

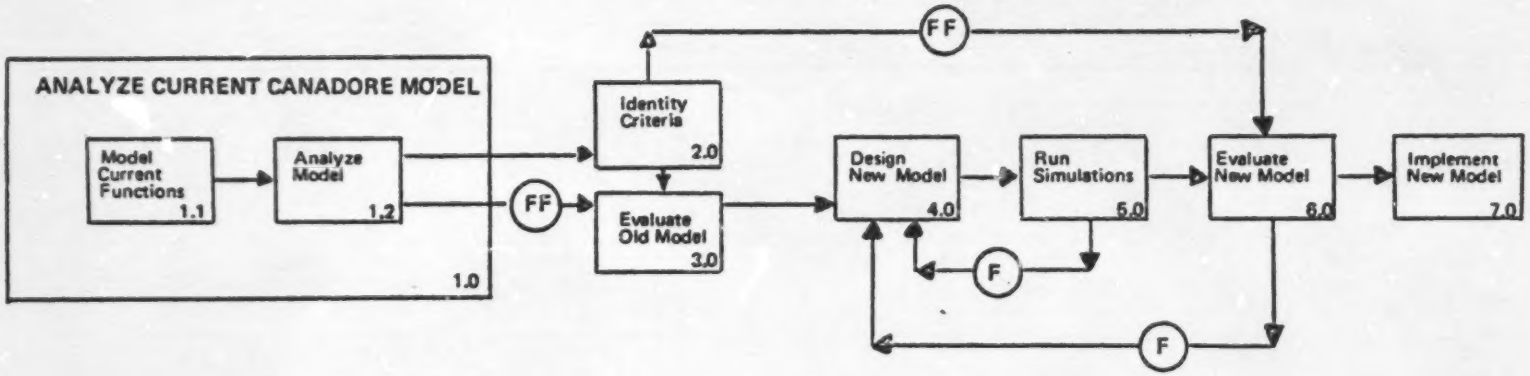

ANALYZE CURRENT CANADORE MODEL
Model Current Functions 1.1
Analyze Model 1.2
1.0
FF
Identity Criteria 2.0
Evaluate Old Model 3.0
FF
Design New Model 4.0
Run Simulations 5.0
Evaluate New Model 6.0
Implement New Model 7.0
F
F

Figure 3

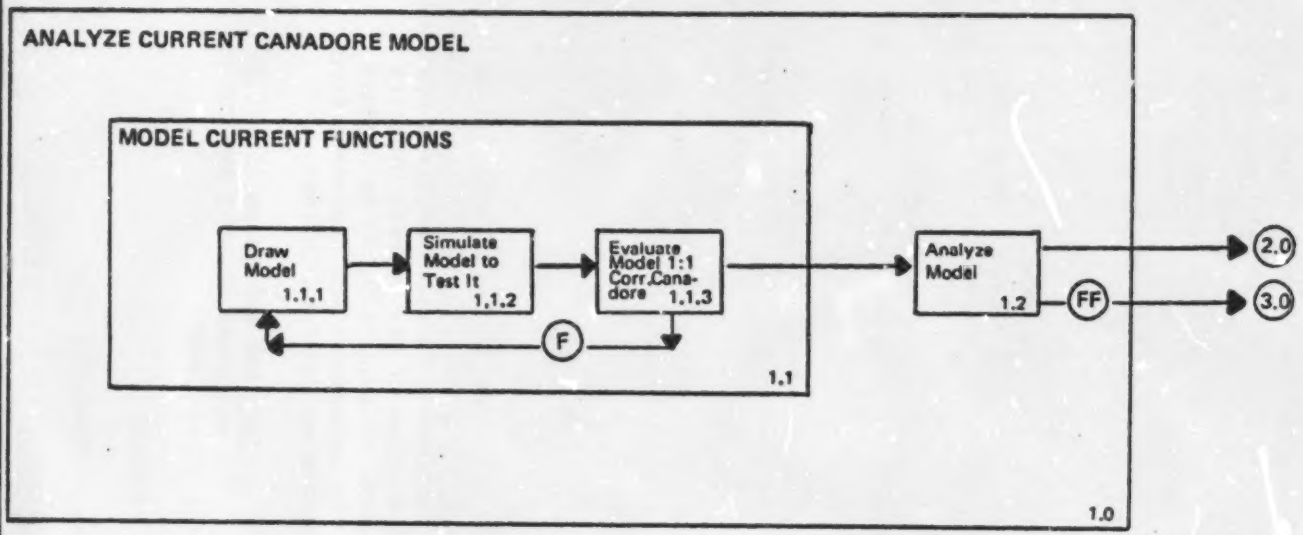

ANALYZE CURRENT CANADORE MODEL
MODEL CURRENT FUNCTIONS
Draw Model 1.1.1
Simulate Model to Test It 1.1.2
Evaluate Model 1:1 Corr.Cana-dore 1.1.3
F
1.1
Analyze Model 1.2
FF
2.0
3.0
1.0

Figure 4

individualizing and personalizing developed and used, as well as a complete description of all administrative, faculty, and paraprofessional functions. In subsystem (1.1.1), the objective is to produce a model of present functions which has a 1:1 correlation with the actual program. In subsystem (1.1.2) we simulate the model to test it and in subsystem (1.1.3) the model is evaluated as to whether or not a high "fidelity" with the real life situation has been achieved.

In subsystem (1.2), the current model is analyzed. Signal paths from (1.2) to (2.0) and (1.2) to (3.0) indicate that the next step is to identify the criteria used to evaluate the old model. The results of analysis of the current situation in (1.2) are fed forward to (3.0) where the current model will be evaluated. Criteria for evaluation (2.0) are used in (3.0) to evaluate the old model and are fed forward to (6.0) where it is stored as information to be utilized when the new model reaches the evaluation stage in (6.0).

The goal is to analyze the existing situation (1.0), design a new model (4.0), run simulations to test this new model in (5.0) and implement the new model in (7.0).

The subsystem (1.1.1) DRAW MODEL contains two subsystems and is shown in Figure 5:

(1.1.1.1) CONDUCT PROJECT

(1.1.1.2) CONDUCT BTSD PROGRAM

For two years, programs were individualized and personalized without the benefit of research or project assistance. It was learned that additional funds were needed to solve problems that were occurring from individualized programs. The Research Section of the Ontario Ministry of Colleges and Universities was requested to grant $70,000 to conduct a research and development project in the management and implementation of individualized and personalized programs at Canadore College.

Subsystem (1.1.1.1) represents the project and subsystem (1.1.1.2) represents the resulting BTSD Program. The subsystem CONDUCT PROJECT (1.1.1.1) shown in Figure 5 contains ten subsystems:

(1.1.1.1.1) CREATE NEW MINISTRY PROPOSAL

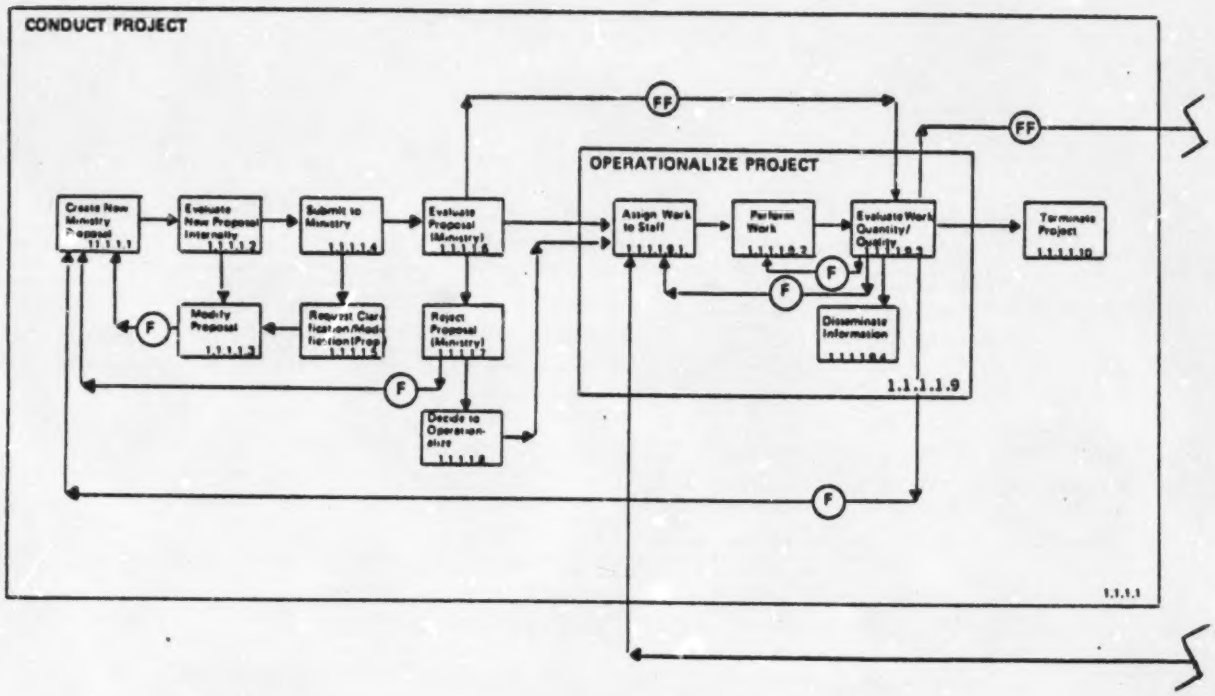
(1.1.1.1.2) EVALUATE NEW PROPOSAL INTERNALLY

(1.1.1.1.3) SUBMIT PROPOSAL TO MINISTRY

(1.1.1.1.4) REQUEST CLARIFICATION/MODIFICATION PROPOSAL

(1.1.1.1.5) MODIFY PROPOSAL

(1.1.1.1.6) EVALUATE PROPOSAL


CONDUCT PROJECT
OPERATIONALIZE PROJECT
FF
FF
F
F
F
F
Create New Ministry Proposal
Evaluate New Proposal Internally
Submit to Ministry
Evaluate Proposal (Ministry)
Assign Work to Staff
Perform Work
Evaluate Work Quantity/ Quality
Terminate Project
Modify Proposal
Request Clarification/Modification (Prop)
Reject Proposal (Ministry)
Disseminate Information
Decide to Operationalize
1.1.1.1.9
1.1.1.1

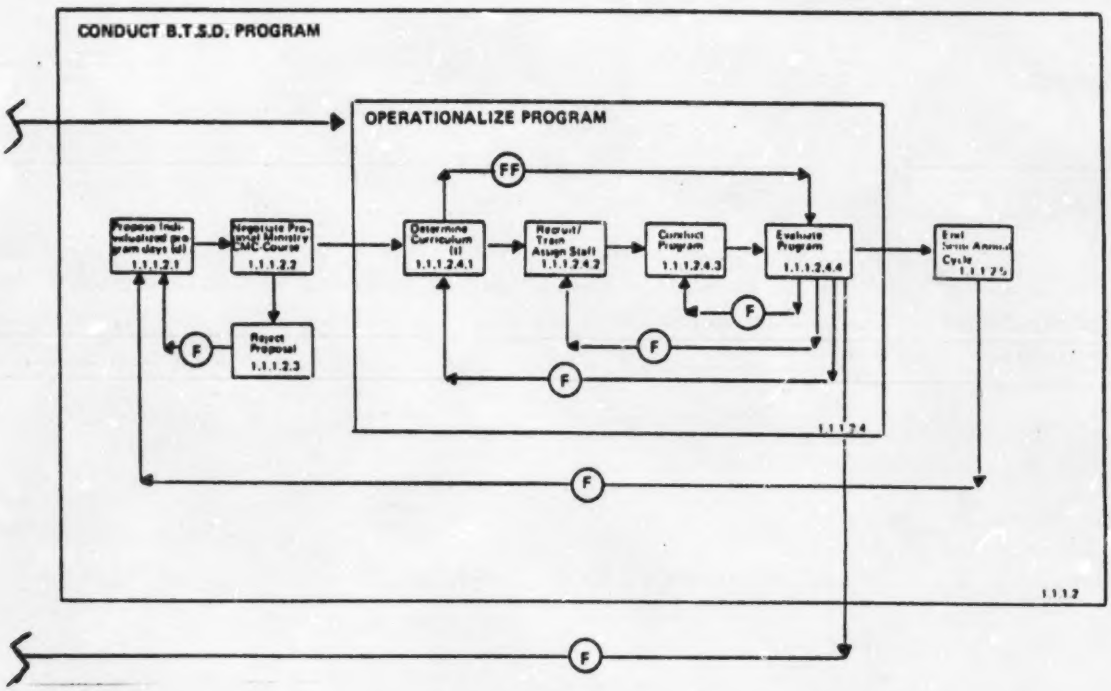

CONDUCT B.T.S.D. PROGRAM
OPERATIONALIZE PROGRAM
FF
F
F
F
F
Propose Individualized program days (s)
Negotiate Proposal Ministry EMC Course
Reject Proposal
Determine Curriculum (s)
Recruit/ Train Assign Staff
Construct Program
Evaluate Program
1.1.1.2.4.1
1.1.1.2.4.2
1.1.1.2.4.3
1.1.1.2.4.4
1.1.1.2.4
1.1.1.2.1
1.1.1.2.2
1.1.1.2.3
1.1.1.2
1.1.1

Figure 5

(1.1.1.1.7) REJECT PROPOSAL

(1.1.1.1.8) DECIDE TO OPERATIONALIZE

(1.1.1.1.9) OPERATIONALIZE PROJECT

(1.1.1.1.10) TERMINATE PROJECT

Subsystem (1.1.1.1) permits use of a model to advantage in project work. Subsystem (1.1.1.1.8) indicates that some functions of the project work are so critical that a way must be found to operationalize those functions even if Ministry funding is not forthcoming. Subsystem (1.1.1.1.9) has four functions. The most important function here is (1.1.1.1.9.3). This subsystem receives input from the feedforward signal path from (1.1.1.1.6). Subsystem (1.1.1.1.9.3) is the key to the implementation phase of all Continuing Education Division project work and all project results are, after evaluation in (1.1.1.1.9.3), fed forward and utilized in the subsystem (1.1.1.2.4) OPERATIONALIZE BTSD PROGRAM. In similar fashion, all problems arising in the day to day operation of the BTSD program are fed back from (1.1.1.2.4) to (1.1.1.1.9.1) which integrates research and implementation and permits researcher and line manager to work together to solve mutual problems and to develop and implement new ideas and findings.

The subsystem (1.1.1.2) CONDUCT BTSD PROGRAM contains five subsystems:

(1.1.1.2.1) PROPOSE INDIVIDUALIZED PROGRAM DAYS

(1.1.1.2.2) NEGOTIATE PROPOSAL

(1.1.1.2.3) REJECT PROPOSAL

(1.1.1.2.4) OPERATIONALIZE PROGRAM

(1.1.1.2.5) END SEMI-ANNUAL CYCLE

A block of training days is proposed to the Ministry of Colleges and Universities and Canada Manpower Centre for a six-month period in (1.1.1.2.1), negotiations occur in (1.1.1.2.2), and the program is either operationalized in (1.1.1.2.4) or the proposal is rejected in (1.1.1.2.3).

Feedback is shown from (1.1.1.2.3) to (1.1.1.2.1); and from (1.1.1.2.4.4) to (1.1.1.2.4.3), (1.1.1.2.4.2), (1.1.1.2.4.1); and from (1.1.1.2.5) to (1.1.1.2.1); (see figure 6).

Subsystem (1.1.1.2.4.3.1) CONDUCT INSTRUCTION is shown in Figure 7. Subsystem (1.1.1.2.4.3.1) contains eight functions:

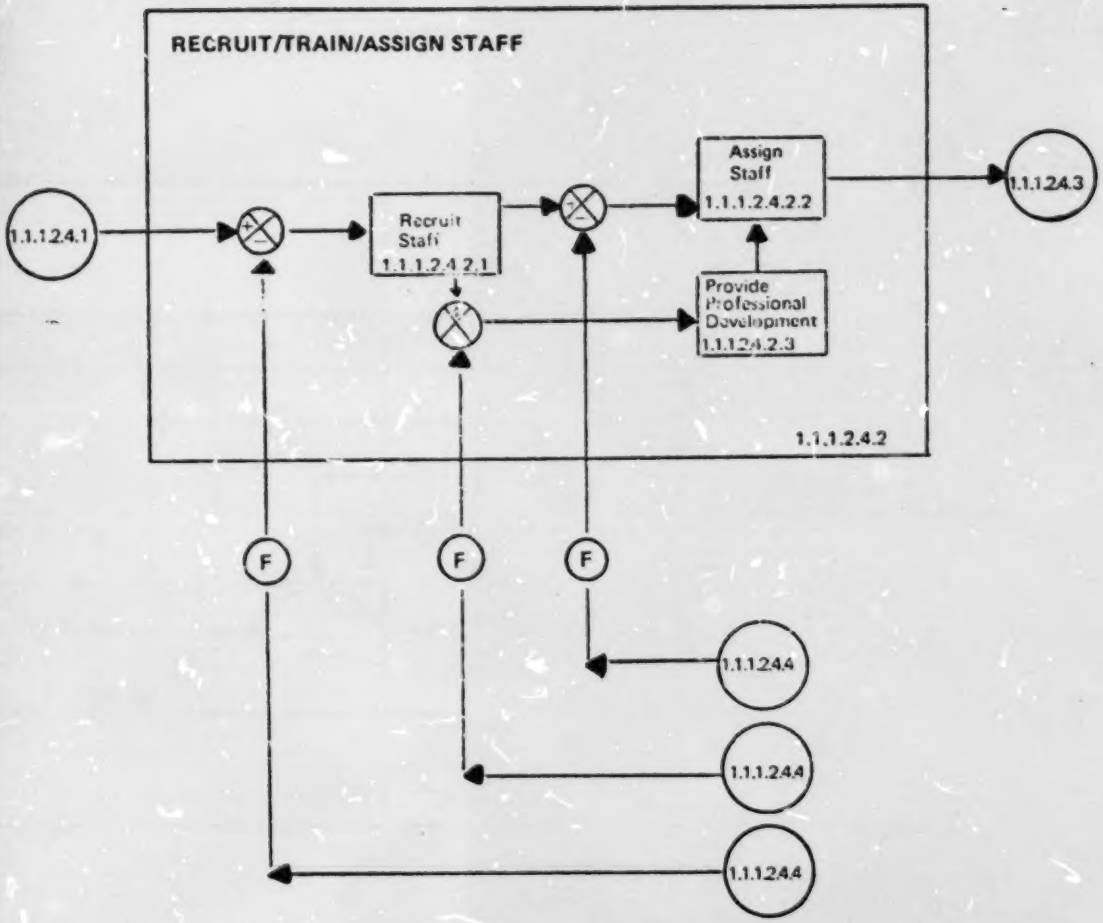

RECRUIT/TRAIN/ASSIGN STAFF
1.1.1.2.4.1
Recruit Staff
1.1.1.2.4.2.1
Assign Staff
1.1.1.2.4.2.2
1.1.1.2.4.3
Provide Professional Development
1.1.1.2.4.2.3
1.1.1.2.4.2
F
F
F
1.1.1.2.4.4
1.1.1.2.4.4
1.1.1.2.4.4

Figure 6

97

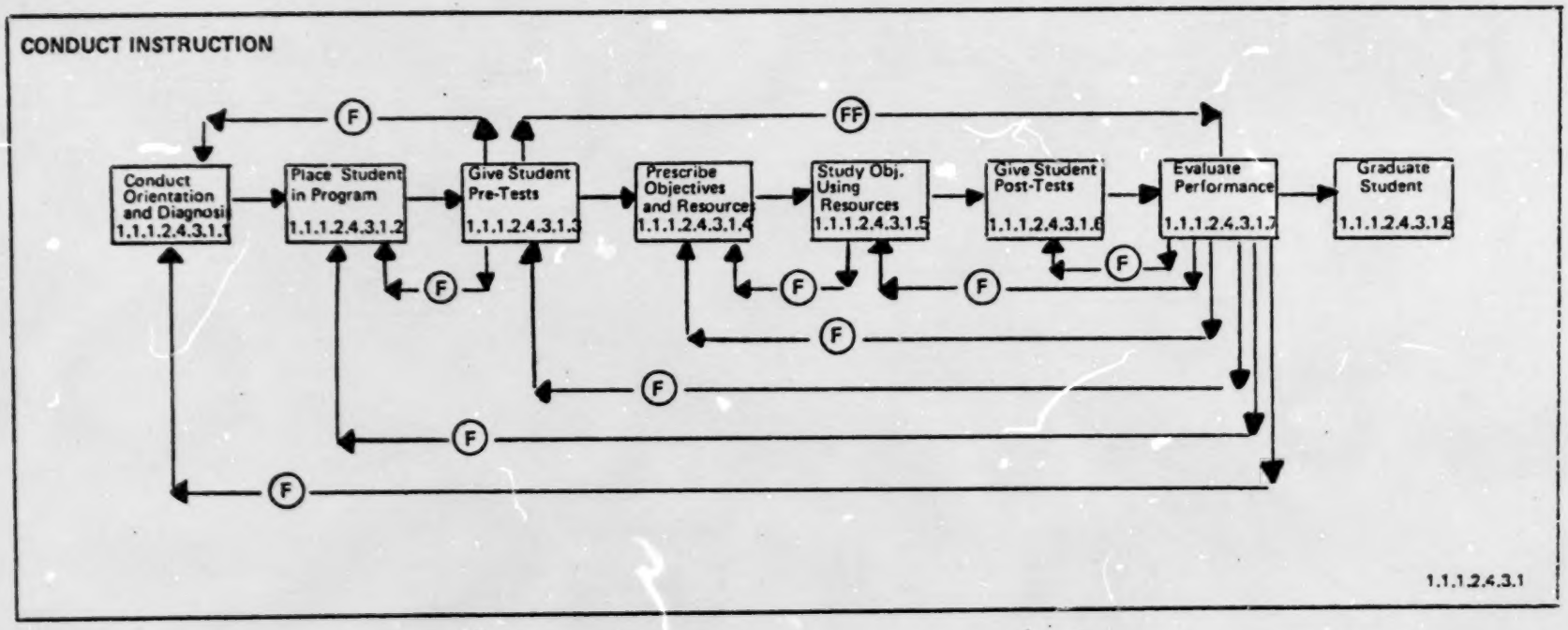

CONDUCT INSTRUCTION
F
FF
Conduct Orientation and Diagnosi 1.1.1.2.4.3.1.1
Place Student in Program 1.1.1.2.4.3.1.2
Give Student Pre-Tests 1.1.1.2.4.3.1.3
Prescribe Objectives and Resource 1.1.1.2.4.3.1.4
Study Obj. Using Resources 1.1.1.2.4.3.1.5
Give Student Post-Tests 1.1.1.2.4.3.1.6
Evaluate Performance 1.1.1.2.4.3.1.7
Graduate Student 1.1.1.2.4.3.1.8
1.1.1.2.4.3.1

Figure 7

(1.1.1.2.4.3.1.1) CONDUCT ORIENTATION AND DIAGNOSIS

(1.1.1.2.4.3.1.2) PLACE STUDENT IN THE PROGRAM

(1.1.1.2.4.3.1.3) GIVE STUDENT PRE-TESTS

(1.1.1.2.4.3.1.4) PRESCRIBE OBJECTIVES AND RESOURCES

(1.1.1.2.4.3.1.5) STUDY OBJECTIVES USING RESOURCES

(1.1.1.2.4.3.1.6) GIVE STUDENTS POST-TESTS

(1.1.1.2.4.3.1.7) EVALUATE PERFORMANCE

(1.1.1.2.4.3.1.8) GRADUATE STUDENT

The model is now at the eighth level of detail. At this level of detail the function of instruction is still in gross overview format. By using this system it is possible to systematically take each function to lower levels of details, or higher resolution, and present an exact representation of instruction. Also, at eighth level of detail. subsystem CONDUCT INSTRUCTION is complex but the goal of considering the elements on individualizing and personalizing and their interrelationships with high resolution and without finding a situation which is too complex for the system can be accomplished. Subsystem (1.1.1.2.4.3.1) CONDUCT INSTRUCTION represents a situation in which the total program is individualized and personalized. This subsystem contains the details of all of the elements and interrelationships referred to in "Arriving at Individualization and Personalization" (Dudgeon, 1973) and "Innovative Approaches to Adult Basic Education" (Dudgeon, 1973, B.T.S.D. Review).

Elements Used in the Canadore Model

The process of individualizing and personalizing instruction is made up of a large number of elements. Some of these isolated elements are: performance objectives, pre-tests, post-tests, criterion-referenced measurement, computerized data banks of objectives, items and resources, innovative architecture, the Educational Sciences including the cognitive styles of administrators, faculty, counselors and students, mediation by design rather than chance, computer-managed tracking, computer-managed evaluation, computer management of instruction, instructors utilized as resource persons, peer tutoring, paraprofessionals, a variety of hardware and software, diagnosis of learning problems, prescriptions, measurement of retention, the use of sampling technique in evaluation to introduce economy into testing, objectives written with attention to taxonomic levels, sequencing of content from the lowest to highest across levels, a balance between cognitive and affective objectives. These elements were not listed in the order implemented, but the list serves to prove that an instructional systems technology model for change contains a great many elements. These elements are all complex. The elements and interrelationships are complex and the process of anasynthesis is needed to obtain solutions in complex systems.

Methods and Techniques

In the Continuing Education Division at Canadore, the elements of individualization and personalization are combined to meet the needs of each individual student. Each student has his/her own individual rate of learning and his/her own learning style.

Use of Lecture and Seminar

The use of lecture or seminar depends on the student. Some students learn best by lectures and good lecturers must be provided to fill this need. There is nothing more damaging than to place a student, who does poorly in a group, into a seminar where the person will be expected to participate in order to achieve the objectives. If a seminar experience is necessary for a student's chosen vocation, and if he/she does poorly in groups, then this should be identified prior to instruction and augment the student's group-interactive abilities before expecting the student to attend and do well in a seminar. Many schools simply place this student in a seminar and leave him/her to sink or swim.

There are many instructional techniques: lecture, seminar, lecture-discussion, tutorial, peer-tutoring, independent study, Computer Assisted Instruction (CAI), programmed instruction, and others. Consider the problems when these modes are combined or interrelated with print, audio, visual, audio-visual, and all of the other varieties of presentation format. The situation becomes very complex when considering the alternate media available for each mode: television, books, radio, audio tape, video tape, theatre, sociodrama, film and real life field experiences, slides, and computers.

Use of Computer Managed Instruction (CMI)

Computer Managed Instruction (CMI) permits college managers to utilize a computer in managing the process of individualization and personalization. When programs are individualized, a great deal of complex information must be available to managers to avoid chaos. Imagine a college where 10,000 students are each receiving instruction based upon their individual needs. In a situation like this, a computer can be used to provide, in a sophisticated and economical way, management information needed. A computer can be used in management of individualized and personalized programs. A computer can further be used in the evaluation process. Step by step process of large numbers of students can be easily monitored by computer. Pre-test, post-test and retention data can be obtained without armies of clerks usually associated with individualized learning. Concepts such as objective, item, and person sampling techniques can be utilized. Sampling techniques and a computer can greatly reduce both frequency and cost of achievement testing. A computer can be used to give computer assistance to such difficult jobs as curriculum validation and analysis. CMI can be used to help determine and allocate resources during operation of individualized and personalized programs. In short, possible uses of a computer in the management of instruction and education programs has only begun.

Application of Cognitive Style

Concepts such as cognitive style have an almost infinite number of applications in individualized and personalized programs. Cognitive style was developed by Dr. Joseph E. Hill (1971) based upon four assumptions about the human being:

1. Education is the process of searching for meaning.
2. Thought is different from language.
3. Man is a social creature with a unique capacity for deriving meaning from his environment and personal experiences through the creation and use of symbols.
4. Not content with biological satisfactions alone, man continually seeks meaning.

Hill (1971) defined seven educational sciences which were based on these assumptions. The seven educational sciences include:

1. Symbols and their meanings
2. Cultural determinants of the meaning of symbols
3. Modalities of inference
4. Biochemical and electrophysiological aspects of memory
5. Cognitive styles of individuals
6. Teaching styles, administrative styles, and counseling styles
7. Systemic analysis and decision making

An individual's cognitive style is determined by the way of taking note of the total surroundings: (1) how meaning is sought, and (2) how information is learned. Is the individual a listener or a reader? Is the individual concerned only with his/her own viewpoint or is the individual influenced in decision-making by family or associates? Is reasoning performed as a mathematician, or as a social scientist, or as an automotive mechanic?

The commitment of the Canadore Continuing Education Division is to: (1) determine the cognitive style of a student, (2) adapt instructional strategies to that style to guarantee successes, and (3) augment in a designed manner weaknesses of a student.

Use of a Confluent Approach

Most successful innovative, individualized and personalized educational programs are based upon a blend of cognitive and affective strategies. The affective domain is often required and it needs to be emphasized. One successful approach to affective strategies and outcomes

is to adopt a strategy which blends both a behavioristic and a humanistic orientation to the affective domain. This behavioristic-humanistic approach can also be used with the cognitive domain.

There is a need to emphasize education for the total person. That does not sound too new and it is certainly not a new idea. The Greeks saw this as the only worthwhile education. No aspect of the human potential was left to lie dormant. Knowledge, culture, athletics, human values and awareness were all a part of what Plato and Aristotle practiced every day of their lives.

The modern age has found itself caught up in technology. Children have to be able to function within a modern technological environment. The use of technology in education should not be dehumanizing; and attention should be given to the emotional aspect of learning. In order to guarantee success on the intellectual side, the feeling component that accompanies every process has been ignored.

There is a growing recognition that education must equip a student to cope in a technological environment and cope in such a way that no part of his or her human potential will be ignored. This new approach is called confluent education. Confluent education is a philosophy and practice that takes into account both the intellectual demands of the complex society and human potential needs of each individual student. Dr. George Brown (1972) defines confluent education as follows:

> Confluent education is the term for the integration or flowing together of the affective and cognitive elements in individual and group learning - sometimes called humanistic or psychological education. Affective refers to the feeling or emotional aspects of experience and learning. How a child or adult feels about wanting to learn, how he feels as he learns, and what he feels after he has learned are included in the affective domain.
>
> Cognitive refers to the activity of the mind in knowing an object, to intellectual functioning. What an individual learns and the intellectual process of learning it would fall within the cognitive domain unless what is learned is an attitude or value, which would be affective learning. (p.3-4)

Confluent education can only come about by a re-thinking on the part of colleges. There needs to be a reintroduction of what has gradually eroded since the time of the Greeks; the affective or emotional aspects of experience and learning: (1) how a student feels during learning, and (2) how a student feels after learning.

The concept of confluent education is paralleled in the writings of the contemporary European philosopher Martin Heidegger. Heidegger's claim is that there is no intellectual process which exists in separation from an emotional counterpart. Emotions are just as much a part of the student in the classroom as are his or her intellectural abilities. Students have been asked to demonstrate their intellectual achievements and then judged

on the content of the subject matter alone. But the graduates cannot exist on subject matter alone. Graduates who can cope in a world demanding more than knowledge of subject matter content are needed. New emphasis must be placed on the total human being with all of his or her potential for intellectual and emotional growth.

Educators need to re-think the emphasis in education. To emphasize only subject content and ignore emotion cannot continue. A program of confluent education for the total person by building into education programs situations that enhance emotional learning and growth as well as subject content should be emphasized and implemented.

A Strategy for Change

Educational change or changing should focus on the attainment of better learning outcomes and an attempt to reach each learner as an individual. One strategy for institutional change involves college managers who adopt, as policy, a commitment to permit innovative personnel to develop and implement their ideas. Any good change agent will be ineffective if college policy or senior administrators block the way.

Administrators should encourage the eclectic selection of the elements of instructional systems technology that will improve upon the efficiency in the management of learning. In this climate, administrators can hold all members of their organization responsible and accountable for student learning outcomes and the accurate measurement of learning. Administrators should not take a rigid position and must permit a blend of behavioristic and humanistic approaches to both the cognitive and affective domain.

Cost of Institutional Change

Many colleges now have enough hardware for an individualized and personalized process but it may be either seldom or ineffectively used. Education tends to be a labor-intensive business and the redeployment of resources based on educational technology and an instructional systems approach can lead to savings. Research and development has to be done and in the early stages this may negate cost savings but the end results will demonstrate trade-offs and payoffs in cost savings. Development cost, like any other cost, should be amortized (Wilkinson, 1972). The cost benefits and savings are two of the many benefits of individualized and personalized education programs,

The Role of the Educational Development Officer

One key to institutional change is the change agent. In an instructional systems technology model for institutional change, the educational development officer (instructional systems technologist) can be a key change agent. Educational development officers can be

trained to implement systems, and then support and train administrators, instructors, paraprofessionals, and students, during and after the implementation of these systems. The level of implementation and the frustration of faculty and students will vary with the degree of expertise of the educational development officer. Therefore, educational development officers must be carefully chosen and trained by administrators.

Role of the Instructional Manager

Systematic management of learning demands that instructors become instructional managers who can design and manage the learning process. Computer systems, both computer managed instruction (CMI) and computer assisted instruction (CAI), are available to assist an instructional manager in his or her role. Computers can collect and tabulate evaluation data and dispense information; however, the instructional manager must apply professional judgment to the information or data in the role of designer and manager of learning. The instructional manager is the diagnostician, the professional resource person, the prescriber of instructional material and the interpreter of evaluation data. Innovative approaches to the management of instruction are an integral part of a process of institutional change in an instructional systems technology model.

Future Challenges

Education has changed and is continuing to change. There is concern about communication of educational innovation, and innovation diffusion and adoption. There is a need to concentrate on training instructional systems technologists who can act as change agents in institutions that wish to develop instructional systems models for institutional change.

The problem seems to be whether or not the concepts and techniques which are currently available to provide more effective instruction can be combined. Many institutions have become dissatisfied with the process because they do not either utilize enough techniques to solve problems and/or seek ways to integrate and maximize effect of various concepts and techniques of instructional systems technology.

The future challenge is to develop concepts, techniques, and implementation strategies of instructional systems technology to provide for individualized and personalized education.

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MANAGEMENT MODELS, ORGANIZATIONAL MODELS AND INSTRUCTIONAL MODELS

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Introduction

Models and model building have been around a long time. They intend to describe or predict results, either current or future. Models have different referents; some are for subsystems, some for systems, some for both. Different models tend to be confused by both users and practioners. This paper describes some different types of models and introduces a possible interrelationship among them. Implications for military applications are presented.

This paper deals with three types of models:

1. Management Models
2. Organizational Models
3. Instructional Models

Each type of model is useful, each type can either describe or predict, and each type tends to be confused with the others by both designers and implementers (Morgan, 1975). This does not have to be the case, and this paper (1) defines each type and (2) relates each type to the others.

Management Models

Management models are designed to identify functions which have to be performed to manage change or to orchestrate the status quo. Management rules differ in the extent to which they identify change requirements and determine validity for change and/or maintenance of an organization. Management models are usually generic in nature and might well include organizational models and instructional models in some applications.

A management model will be typified here by Kaufman's (1972) system approach. This approach has six steps, which include problem identification, as well as problem resolution. This model can predict as well as describe; and begins with an assessment of needs as a precursor to any management of change, instructional, organizational, or other.

This six-step approach model is systematic while purposive. This model does not concern itself with description, but identifies as well as solves problems.

The six steps of this model include:

(1.0) Identify problem based upon needs

(2.0) Determine solution requirements and identify solution alternatives

(3.0) Select solution strategies from among alternatives

(4.0) Implement solution

(5.0) Determine performance effectiveness

(6.0) Revise model as required

This process is generic; it has two major parts:

1. Problem identification, verification and validation: Functions (1.0) and (2.0)

2. Problem resolution: Functions (3.0), (4.0), and (5.0).

Both parts have steps for revision.

The intention of this type of model is to manage change or to manage the continuation of some valued set of procedures and outcomes. One hallmark of this model is attention to what is to be accomplished at each function in the mission profile, not starting with, or even selecting hows until the (3.0) step or function. This management model may be used anytime there is a requirement for planning and doing, and when there are no premises which must be followed regardless of validity.

Organizational Models

Organizational models are designed to change the way in which people and things interact, in order to meet goals and objectives of organizations. These models have tended, in recent years, to be more humanistic and emphasize the extent to which outcomes may be enhanced or improved by focusing on people as human beings and not as things. Work in this area was well summarized by Hersey and Blanchard (1972) and was integrated in their Life Cycle Theory Model. This model may be useful to describe current organizational interactions and also to identify possible new organizational patterns and interrelationships.

The most familiar organizational model is the organization chart. These models show the relationships between functions and people; where people work, how they are supposed to interact, and the general flow of lines of authority. Like other models, there is much mysticism and ritual associated with these models, and like other models, use of one or another is based more upon faith and face validity than upon empirical data.

Associated with organizational models are organizational development models which are intended to make organizations work better. These models may vary from guides for use of time and specification of goals and objectives to the way in which persons can more effectively and efficiently interact. Most organizational models are more descriptive than predictive, and change generally depends upon decisions of one or more people within an organization.

Instructional Models

Instructional models generally relate to bringing about individual and group change, once useful objectives have been identified. These models are systematic, and are effective if used properly. Typical of this type of model is the Instructional Systems Design model of Florida State University (Branson, et. al., 1975).

Instructional models are targeted-purpose models which are intended to change some specific set of existing circumstances within a given organization. Validity of that organization and usefulness of training, education, or management development is taken, generally, as being valid and useful.

Most models used in organizational change are, in fact, instructional models since they are designed to make things better within an organization, rather than to change organizational purposes or the environmental context within which an organization operates and/or obtains its sustenance.

Interrelationships Between Models

Interrelationships between these types of models are optimal when there is a use of all types of models as required. Management models will identify and validate organizational purposes, and identify overall functions to be performed to achieve the validated purposes. Organizational models, while relating to validated requirements, will help to utilize personnel and resources in an optimal way to meet validated outcomes. An organization then might use a valid instructional model to actually change required behaviors which were found to be necessary. Thus, there is a set-sub-set relationship between these various types of models.

Management models determine what should be done so that how-to-do-its become more responsive and responsible. A generic management model could identify, validate, and select problems before selecting appropriate methods and means for resolving problems. Management models are over-all, big-picture models, and are useful when an organization might be interested in and/or able to effect dramatic shifts in purposes and outcomes. For example, a general management model might well have led to some very different purposes, methods-means and outcomes if applied to the Pennsylvania Railroad, the New Haven Railroad, W. T. Grant, the

Vietnam War, or the War on Poverty. Useful management models here separate means and ends, and determine valid ends, not just measurable ones.

Organizational models can be used to organize persons and resources once valid outcomes have been established, and methods and means such as personnel, buildings, and money, have been selected and obtained. Thus, a horizontal organization, or a theory Y type of atmosphere may be chosen. The key element in understanding this type of model is that the model is designed to interrelate known resources to meet already established ends. Validity of outcomes is not questioned or questionable; the only variable is how to achieve valued ends in a more effective and efficient manner.

Instructional model is another type of targeted instrument. When instruction is appropriate, then instructional models are used to manage design, implementation, evaluation, revision, and renewal of valuable learning outcomes. The model is based on reliable and valid information that training is necessary, and that the resulting behavior changes will be useful to an organization. In the military, for instance, it is noted that training is a premise and there are large and often monolithic sub-agencies to do this. It is often a matter of great conjecture, however, whether military training is responsive to present problems; but poor, inadequate, or non-existant evaluation procedures shield trainers and training designers from determining if training was, in fact, a viable solution to extant problems.

One interesting aspect of the management model is its generic nature. This type of model can be used to manage any kind of situation, either organizational, training, evaluation, or all of these. Any time there are problems to be identified and resolved, a management model, in some form, is useful. To accomplish any function in the six-step management model simply requires repeating the same six steps specific to that particular function. Thus, to attempt to accomplish a (4.0) function, IMPLEMENT SELECTED STRATEGY, gaps between current and required state of affairs for implementation are determined, detailed requirements and alternatives are determined, methods and means are selected for that implementation, effectiveness of those methods-means are determined, and revisions as required are made. The six steps are repeated. Any model for a (4.0) function would have those functions, and if any useful model were analyzed, such as an instructional model or an organizational model, the generic six steps would be there inbedded. Now this fact seems almost too simple at first. There is a uniformity in approaches for most useful models; the six steps of a generic management model. The differences between these models lie primarily in the starting places; with the outcomes desired, and the assumptions made.

In the case of an instructional model, it is assumed that the outcome should be some trained personnel; in an organizational model the outcome should be some organized persons and resources. This concept fits with previous suggestions relative to a taxonomy of planning (Kaufman, 1971, 1972) and a possible taxonomy of needs assessment models (Kaufman, 1976).

Applications of Models

It is not a matter of which one of these models to use. They all are used and are usable, in the military, in industry, and in education. The military, like most organizations, tends to use organizational models and instructional models, but true and generic management models bring up too many questions of basic values and purposes. Questions such as, should there be an Air Force, are best not asked except by persons of great power, such as Secretaries of Cabinet rank, senators, senior congress-people, newspaper reporters, and syndicated columnists, because each lower echelon person tends to feel that this is not his responsibility, and hopes that those giving the assignments know what they are doing.

Thus, one tenet of this paper is that a useful management model brings up basic, fundamental questions of validity of purpose, not just how to better manage that which is going on. Each person in any organization is capable of asking fundamental questions about organizational purpose and validity, and persons asking such questions, even if not of national stature, deserve some answers which make sense.

This is not to say that following policies is not important or necessary, it is suggesting that while on the way to meeting objectives, there need to be answers relative to why objectives should be met. Validity of purpose is more fundamental than reliability of methods.

Military organizations can be pathfinders in implementing new responsiveness and responsibility in management and accomplishment by beginning to separate and better interrelate these three types of models. Other organizations will follow this lead, especially if they intend to be cost-efficient, cost-effective, and successful.

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IMPLEMENTATION OF INTERSERVICE PROCEDURES FOR INSTRUCTIONAL SYSTEMS DEVELOPMENT: A PLANNED PROCESS FOR CHANGE

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Introduction

As stated in the proposal concerning the Implementation of Instructional Systems Development at a Selected Army School:

> The principal purpose behind the entire study is to optimize the allocation of training resources to meet clearly defined needs within the context of current command guidance; that is, increases in efficiency and effectiveness of resident instruction, improvements in the quality and quantity of non-resident instruction, elimination of resident training which can be reasonably accomplished on-the-job or through the use of Job Performance Aids, and finally, the institutionalization of systematic approaches to training management specified in the Interservice Instructional Systems Development Program.
>
> A second fundamental purpose of the study is the design of an evaluation plan for the collection of data on the field use of procedures in order to refine, upgrade, and improve them through time. It has been repeatedly demonstrated that working with individuals required to use "imposed" procedures in a real-world context most often leads to improvements in the recommended procedures and increases in the local acceptance of those procedures. It is fully expected that the entire set of procedures would be revised and upgraded as a result of the implementation effort. (Branson, 1975)

In order to promote change many authors (Becker & Hahn, 1975; Armsey & Dahl, 1973; Kaufman, 1972; Schaller, 1972) agreed that a process for change should be planned. Although changes do occur without such planning, unplanned results have an equal probability of falling into a number of categories which may range from a totally successful and useful change to an unsuccessful and unuseable change, that is, if one can determine what is and what is not successful. Use of a planned process for change enlarges the capability of making a more pointed determination of success. This planned process increases probability of causing change in a desirable direction as well as ability to measure the degree of successful change.

Institutionalizing change is not an easy, no-fault process even with the best possible plan in the hands of a change agent. Kaufman (1972) stated that change may be an extremely painful experience for some people. Consequently, change seems to be a threatening circumstance. Comments about the threatening nature of change are shared by many authors who deal with change agentry. Institutionalization of any innovation is usually disruptive and resistance is practically an automatic response.

However, enough is known about the process of change that assistance can be given to others to plan change. Schaller (1972) based The Change Agent on the following assumptions:

1. people can profit from experiences, reflections and insights of others;

2. by action or by inaction every person does influence the future;

3. violent revolution is not a viable alternative in the United States today;

4. The person who has a systematic approach to the future and a frame of reference for evaluating alternatives has a tremendous advantage over the person who functions without either.

What Schaller seemed to suggest in The Change Agent was that there is an awesome amount of data which can be drawn upon to increase probability of acquiring desired changes. This knowledge of a change process, along with some faith, can reap fruitful results.

Once convinced that a planned change effort has a greater probability of acquiring desired responses, the next step involves identification of those elements which constitute such a plan. A number of models have been developed to assist in implementation of technological innovations. Each of these models is consistent in that it refers to similar phases or stages of a plan for change, including: (a) needs analysis, (b) identification of discrepancies, (c) alternative solution development, (d) implementation, and (e) evaluation and revision. It is also generally accepted that this is a continuous process which ends only with achievement of desired outcomes. It should be noted that desired outcomes may also be revised in such a system.

Model Implementation

The purpose of this paper is to present a plan for implementing Interservice Procedures for Instructional Systems Development (IPISD) in the United States Army Signal School (USASIGS). This plan also serves as a model for carrying out IPISD in interservice schools.

Armsey and Dahl (1972) stated that the conditions of success in the use of the things of learning are many, varied, imprecise, changeable, and changing. Within this uncertainty, projects that incorporate certain considerations enhance substantially their likelihood of achieving success. Implementation of any new technology requires inputs at appropriate management and technical levels to ensure its chances for survival. Since change is often disruptive and, in many cases, opposed, infiltration of an organization at appropriate levels with positive incentives is a necessary condition for success.

Once the key management levels of an organization have been identified, the product should be sold. A product can be accomplished in a number of

ways, but there are some key considerations. The following model of some of these key considerations was taken from Armsey and Dahl (1972).

1. A field analysis is conducted in which:

   a. a recognized and generally agreed-upon need is identified;

   b. a desire on the part of the organization to meet the need is acknowledged, and

   c. the insight of how instructional technology can be incorporated to meet the need is reached.

2. A process for change is planned, in which.

   a. a purpose must be articulated, to guide functions and discussions;

   b. a structure, which makes success possible, must be identified or developed;

   c. leadership must be exerted at the appropriate levels of management;

   d. technical level workers must participate in and support the project;

   e. an evaluation plan must be provided throughout the duration of the project.

This is not an exhaustive listing of elements; however, phases or categories for planning change are present.

Following the criteria we outlined by Armsey and Dahl (1972), a plan for implementing Interservice Procedures for Instructional Systems Development at United States Army Signal School was developed. This plan included a concept paper on an implementation effort developed by the United States Army Signal School personnel in concert with Combat Arms Training Board (CATB). The concept paper, implementation plan and evaluation plan represented a systematic approach of implementing Instructional Systems Development at the United States Army Signal School. For purposes of illustration, Table 1 indicates how the three documents were correlated with elements of change presented in this report.

It should be noted from Table 1 that nothing in this entire effort lacks flexibility of being revised. The documents could be revised by a project officer and immediate and consulting staffs. It is too early to publish results of this effort since it is still in progress. However, a number of events have taken place which have influenced implementation efforts. Some events were part of implementation/evaluation plans and others stemmed from different actions. In accordance with the plan for implementing Instructional Systems Development at the United States Army Signal School:

Table 1

Correlation Between the Concept Paper, Implementation Plan, Evaluation Plan and the Elements of Change

Elements	Source
1. A field analysis, in which:	
a. a recognized and generally agreed upon need is identified	Concept Paper Evaluation Plan
b. a desire on the part of the organization to meet the need is acknowledged	Concept Paper Evaluation Plan School Model
c. the insight of how instructional technology can be incorporated to meet the need is reached	Implementation Plan
2. A process for change is planned, in which:	
a. A purpose must be articulated to guide functions and discussions	Concept Paper Implementation Plan
b. a structure, which makes success possible, must be identified or developed	Implementation Plan Concept Paper
c. leadership must be exerted at the appropriate levels of management	Implementation Plan
d. technical-level workers must participate in and support the project	Implementation Plan
e. an evaluation plan must be developed	Implementation Plan
f. adequate resources must be provided throughout the duration of the project	Concept Paper

1. Two courses were chosen for the implementation effort, the 31M-MOS (Multichannel Communications Equipment Operator) and the 26 officer course (Fixed Telecommunications Officer).

2. Workshops were conducted at the senior manager, manager and technical levels. These workshops were generally thought of as productive and useful by the United States Army Signal School personnel.

   Approximate numbers of workshop attendees:

Senior Managers	1
Managers	15-20
Technical-Level	32-48

3. The implementation plan was staffed and approved by the Directorate of Training Development at the United States Army Signal School.

4. The evaluation plan was staffed and approval will be sought from TRADOC.

Other actions affecting the implementation effort include:

1. The Interservice Procedures for Instructional Systems Development manuals have become TRADOC Pamphlet 350-30.

2. The New School Model specified functions which correlated practically 1.0 with Instructional Systems Development procedures and separated quality control as an independent function.

3. A Request for Proposals was let which specified use of TRADOC Pamphlet 350-30 by the contractors.

4. Forthcoming training guidance specified use of Instructional Systems Development procedures in development of individual and collective training.

It is easy to see that major steps were taken toward full implementation of Interservice Procedures for Instructional Systems Development within TRADOC Schools in general, as well as within the Navy.

However, despite an effort to plan every step and involve affected parties, there are those who felt Interservice Procedures for Instructional Systems Development was unusable, illogical, imprecise, too technically oriented, and impossible to accomplish. Efforts evolved to abort Interservice Procedures for Instructional Systems Development as it was designed. None of these individuals made a conscious effort to attend workshops, gather data from Instructional Systems Development trained job incumbents or discuss the problems in detail they found associated with this model with those who prepared and assisted in the preparation of the manuals. Consequently, many of their convictions were data-free.

The purpose of the implementation effort was to allow individuals to make data-based decisions on what was good and not good about Interservice Procedures for Instructional Systems Development. A number of suggestions were made and were incorporated in the revised version of the manuals. The implementation plan set forth in this paper was successful, particularly in getting appropriate managers involved in the process. Managers committed themselves and their resources to the implementation of the Interservice Procedures for Instructional Systems Development.

Even with a vast amount of data available on positive effects of using instructional technology for advancement of learning and organizational structuring, very few institutions of learning have been able to change from the more traditional modes of teaching and learning. A large portion of this problem seems to stem from inadequate planning, knowledge, and infiltration of these institutions.

Summary

This implementation effort was a planned process which required training of various personnel at management and technical levels who were involved in Instructional Systems Development and collection of data which reflected the usefulness of Instructional Systems Development in terms of procedures it presented for developing various products, quality of those products and how those products assisted in bringing about more effective and efficient instructional strategies. This implementation effort was also geared toward development of a management system within which Interservice Procedures for Instructional Systems Development could be accomplished, to include an investigation of incentive structures which may have enhanced or hindered such an implementation effort.

The implementation effort then, had a capacity of arriving at clear, data based indications of what was right and wrong with Interservice Procedures for Instructional Systems Development in terms of its usefulness as well as what the surrounding management system would entail in order to secure substantial improvements throughout the Army's training structure. At the same time, the procedures presented in Interservice Procedures for Instructional Systems Development had the opportunity of being messaged and suggestions for revisions made by individuals and organizations whose primary mission was training. It was fully expected that an entire set of procedures would be revised and upgraded as a result of the implementation effort, thus providing a usable and useful tool for implementing instructional strategies which should be effective, efficient, and technically sound.

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COST EFFECTIVENESS OF NAVY COMPUTER MANAGED INSTRUCTION

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Introduction

Critical to any large computer based training system is its cost effectiveness judged both in humanistic and dollar terms. While there have been repeated attempts to develop functional cost effective models for training systems, efforts have tended to implement functional accounting on the one hand, or highly sophisticated model fitting on the other. The purpose of this presentation is to apply a relatively simplistic cost effective model for judging relative benefits of Navy Computer Managed Instruction (CMI). This will then be contrasted with more humanistic outcomes represented by responses from Navy students, instructors, and Instructional Systems Development personnel.

Results

The cost effectiveness model designed by the Center for Naval Analysis provides a clear way of separating out differences between CMI and conventional instruction, as well as identifying common cost elements. Table 1 presents these elements in terms of common as well as unique elements.

Table 1

Cost Elements for Computer Managed Instruction and Conventional Instruction

Computer Managed Instruction Elements	Common Elements	Conventional Instruction Elements
ADP	Supplies	Instructors
Less Instructors	Travel	Support
Less Support	Plant	
Course Conversion	Indirect overhead	
	CNET/CNTT overhead	

For both systems all operational requirements associated with supply, student travel, plant support, indirect overhead, and managerial support would be required. Conventional instruction requires, primarily, a cadre of instructors and associated support personnel. On the other hand, CMI requires a computer which results in the reduction of instructors and support personnel. Cost of course conversion is an additional expense.

For military training situations the cost of student salaries and associated support is the most significant factor. Table 2 gives a comparison of numbers and costs for fiscal year 1973 to fiscal year 1975.

Table 2

Cost Saving for FY 73 to FY 75

Training Factors	Conventional Instruction	Computer Managed Instruction
Student AOB	1632	2,500*
Course Time	196 hours	104.3 hours
Course Reduction	0	46.8%
Projected Student Load Factor for CMI	4699	0
Amount of Savings in Student Salaries	0	10,106,604

*AOB Level Average for Year

It can be seen that CMI allows for an increased number of students while reducing course time. This is a trade-off relationship. This reduction in course time, when costed against salaries of students, yields a savings of over 10 million dollars for the Navy.

In terms of magnitude, the second greatest saving is derived from instructor and support personnel as presented in Table 3. It can be seen that there is a dramatic reduction, approximating 40%, over the two-year period. This yields a savings of $1.6 million.

Table 3

Instructor and Support Personnel Savings

Projected	Conventional Instruction	Computer Managed Instruction
Instructor Levels	187% (25:1 for 4699)	83 (30:1 for 2500)
Projected Support Level	292 (12.1:1 x 4699)	206 (12.1:1 x 2500)
Instructor and Support Level for FY 75	480	289
Cost	$4,170,240 (480 x 8688)	$2,510,832 (289 x 8688)
Cost Saving		$1,659,408

Following the cost pattern in Table 1, Table 4 gives the projected computer cost for the coming six years. It can be seen that approximately $1.6 million was allocated in FY 75 for cost savings.

Table 4

Computer Costs

Fiscal Year	Cost in Millions
75	1.6
76	2.4
77	6.2
78	3.7
79	2.6
80	2.2

Note. Total Computer Costs cover ADP personnel, lease purchase equipment, maintenance, communications, and supplies/support.

In terms of course conversion, the current Navy estimate for converting an hour of conventional instruction to CMI is 50 man hours. This conversion does not include a full Instructional Systems Development (ISD) process. A complete ISD approach with front-end requirement assessment and task analysis is currently estimated to take 80 to 120 hours of effort per hour of instruction. For three courses this yields a requirement of 29,300 man hours, or approximately 14 man-years. Average cost per man year for Navy enlisted instructional personnel is approximately $10,000 or a cost of $140,000. Thus, cost of course conversion becomes relatively nominal when compared to cost savings due to instructional time and instructional staff reductions.

Summary of Monetary Benefits

The Navy CMI system is a highly cost beneficial operation that is estimated to be saving approximately $10.1 million annually. This cost saving estimate ($10.1M) for FY 75 was derived from student salaries (+$10.1 M), instructor and support personnel salaries (+$1.7 M), computer costs (-$1.6 M), and course conversion costs (-$.14 M). Obviously, the first objective on student time savings was the significant factor.

Beyond direct cost benefits, there are benefits to Navy from CMI that need documentation as follows:

1. Studies of other concurrent beneficial effects such as that attributable to a higher performance level at the end of CMI course and the impact of this factor on transference to fleet operations.

2. Reduced attrition and, consequently, higher savings for manpower deployment.

3. Increased work times for first tour personnel being processed through CMI "A" schools.

4. Potential for reducing manning levels given increased competency levels due to this improved form of training.

Course Orientation Responses to Navy Computer Managed Instruction

Given the prior focus on cost savings and relative efficiency of Navy CMI, it would not be surprising if some negative views were expressed by students and instructors. A survey of 370 indicated positive orientation toward CMI from students. Responses were systematically more positive than those found in conventional collegiate instruction. Most importantly, the Learning Center Supervisor, a tutorial type instructor, received even higher ratings than that typically found for professors.

In turn, instructional staff, namely, the Learning Center Supervisors, have a high positive orientation toward CMI. Use of a questionnaire revealed that the Learning Center Supervisors had committed themselves to a new demanding professional role. The Learning Center Supervisors

perceived the benefit of the CMI system in terms of its objective, namely, time saving, and their role, tutoring and counseling, rather than in terms of the more explicit computer functions of test scoring or registration. Thus, the data indicate a significant positive orientation by this group.

In reference to Instructional Systems Development personnel converting courses, CMI is perceived as a positive step forward beyond individualized training. While resistance factors were reported, expecially in terms of perceived reluctance to convert the courses, a majority of ISD personnel rated their roles as challenging within the Navy mission and professionally rewarding. This highly positive level of response is rather unusual for computer based systems, and reflects the high proportion of uniform personnel supporting the effort.

Summary

The Navy CMI system has demonstrated a high level of cost beneficial outcomes as well as positive support from participating students, Learning Center Supervisors, and ISD staff. Consideration of these consistent positive results have posed further research questions, namely, was a total systems approach utilized which yielded positive outcomes, or are there significant CMI components which are the primary cause of positive outcomes, and, thus, could be used in other systems design with or without a computer. Questions dealing with the exact impact of various components within Navy CMI have yet to be elucidated in specific terms. These questions will be answered over the coming decade by Navy training research staff.